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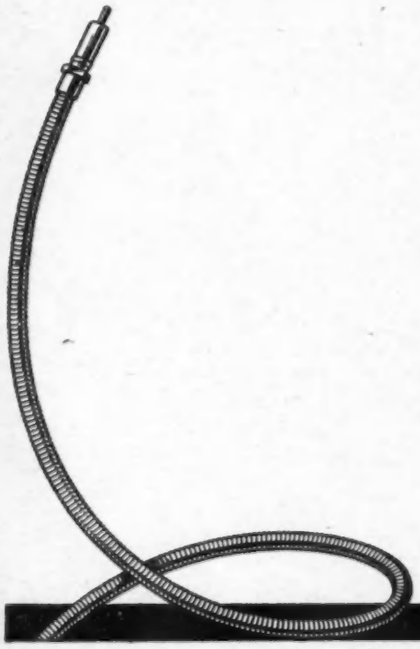

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THE DRIVE FOR VICTORY

THE GRAND COULEE DAM.

(*Continued from page* 362.)

AT the point at which the Grand Coulee Dam has been built, the Columbia River flows through a canyon approximately 1,400 ft. deep, 2,000 ft. wide at the bottom, and more than 5,000 ft. wide at the top. As explained in the previous article, the overburden on the river bed was 40 ft. thick and, at the bottom of the side slopes as much as 200 ft. thick. The actual river channel at normal flow was 800 ft. wide. The drainage area above the dam covers 74,000 sq. miles and the maximum discharge, for the period of 25 years for which records are available, averaged 445,000 cusecs. The greatest flow recorded was 492,000 cusecs. The surface of the water at this discharge was at elevation 981·5; the maximum elevation of the 151 miles long head-pond formed behind the dam is at 1,290. In spite of the enormous size of the Grand Coulee Dam, it does not in itself involve novel features, being a straightforward gravity structure. The mere scale of operations, however, introduced many problems in a new aspect. This will be sufficiently illustrated by the statement that the dam and its ancillary works involved the placing of nearly 12 million cub. yds. of concrete, which is three times that used in the Boulder Dam.

Among the major problems which had to be dealt with, the diversion and control of the river during the construction period was one of the greatest. These had to be planned in reference to the cycle of flow. The river derives the main part of its run-off from snow fall in the Canadian Rockies, and the annual cycle does not show great variations, so that it was possible to arrange with reasonable confidence for the carrying out of critical operations during low-water periods. The conditions ruling, however, imposed the condition that failure to complete some important part of the work during the low-water stage might involve the loss of a year in the construction programme. As mentioned in the previous article, the work was carried out by unwatering the two ends of the site behind cofferdams and constructing the east and west ends of the dam inside them. For the completion of the central section, the river was diverted through a completed section of the spillway and through gaps left for the purpose in the power-house section. The plans were based on the assumption of a maximum river flow of 550,000 cusecs. Actually, the flow while the cofferdams were in use did not exceed 400,000 cusecs.

The west side of the river was first unwatered, the cofferdam being constructed during the winter low-water period of 1934-1935. It was completed before the beginning of high water in April, 1935. The cofferdam, which had a length of 3,000 ft. and enclosed an area of 66 acres, was the largest ever built. Its construction involved the driving of 13,000 tons of steel sheet-piling, of a total length of 667,000 ft. It was constructed in 90 days. Thirty steam pile-drivers were used, handled by jib-cranes and derricks, and operated continuously, day and night. The overburden into which the piles were driven consisted of from 20 ft. to 70 ft. of hard clay interspersed with boulders, sand and gravel. Driving was difficult, and an average of 35 blows of 13,000 ft.-lb. was required per inch of penetration. Refusal was fixed at 80 blows per inch. The piles did not penetrate the bedrock and many were found to be bent when the cofferdam was removed. The sheet piling had to be transported to a railway siding 32 miles away, and for this a number of heavy lorries, varying from 12 to 15, were operated on a 24-hour schedule.

Various different types of piling were used in the construction of the 3,000 ft. west cofferdam, as also for the east cofferdam and the two cross-river cofferdams, inside which the last stage of the work was completed. A plan showing the arrangement of all these cofferdams is given in Fig. 5, on this page. Sections B and I of the west cofferdam consisted of single lines of interlocking sheet piling driven to refusal. At a distance of 37 ft. behind these, timber walls were constructed, connected to the sheet piling by tie rods. The intervening space was filled with spoil. Section H consisted of sheet-pile cells, each 90 ft. by 36 ft. in plan, the ends being formed by arcs of 36-ft. radius. Wide cellular construction was used in this section, in order to provide sufficient stability to enable deep excavation for the tail race to be carried on close to the cofferdam. Sections C and E were of similar construction to section H, except that the cells were 40 ft. by 50 ft. in plan, with arcs of 40-ft. radius at their ends. Sections D and G were clusters of sheet-pile cells which served both as part of the west cofferdam and of the upstream and downstream cross-river cofferdams. The cells were of 40-ft. radius and the internal diaphragms extended only up to elevation 965. Above this, tie rods were used between the cell walls. A part of section H of the cofferdam after completion is shown in Fig. 10, on Plate XXXII. The work shown in progress is the construction of blocks 39 and 40 of the spillway, at an early stage.

When the driving of the cofferdam cells had been completed, the period of high water was approaching and it became necessary to carry out the filling of the cells with spoil with all possible dispatch. This operation required the handling of 275,000 cub. yds. of material. In the early stages, filling was carried out by means of tipping trucks, but when completion became urgent a system of belt conveyors was installed. The filling material was obtained from within the cofferdam area and a belt conveyor was installed connecting the point of excavation with an elevated hopper which was fixed at a point 200 ft. from the inside face of the cells and at about the centre line of section E. A 12-ft. gauge railway track was laid under this hopper and extended parallel to the line of cofferdam cells for a total distance of 1,600 ft. up and down stream. A 48-in. "shuttle" travelling belt conveyor, 870 ft. long, was mounted on timber bents, 14 ft. high. These were supported on 21-in. wheels, which travelled on the 12-ft. gauge track, so that the conveyor could be moved up and down stream a distance of 1,600 ft. The hopper and the conveyor by which it was supplied were fixed, but the shuttle conveyor could be charged from the hopper when it was in any position of the track. Material was delivered to the cells by means of two 36-in. boom-arm conveyors, which were supplied from the shuttle conveyor. One of these is shown in Fig. 9, on Plate XXXII. The inner ends of these conveyors were carried on trucks which travelled on the 12-ft. gauge track, and towards the other end they were supported on turntable mountings carried on timber frames, which travelled on a 28 ft. 6 in. gauge track laid alongside and parallel to the line of the cells. The arrangement is clearly shown in Fig. 9.

The east cofferdam, inside which the eastern end of the dam was constructed, was considerably smaller and shorter than the west cofferdam. It was built up of sheet piling; its form and position can be seen in Fig. 5. This cofferdam, with work on the east end of the dam proceeding inside it, is shown in Fig. 11, on Plate XXXIII. When the photograph from which this illustration was prepared was taken, the west cofferdam, to be seen in the distance on the other side of the river, had been partly dismantled, and the water was being diverted through gaps left in the power-station section on the west side, preparatory to the building of the upstream and downstream cross-river cofferdams.

As already explained, the work carried out inside the west cofferdam covered the construction of the

Fig. 5.

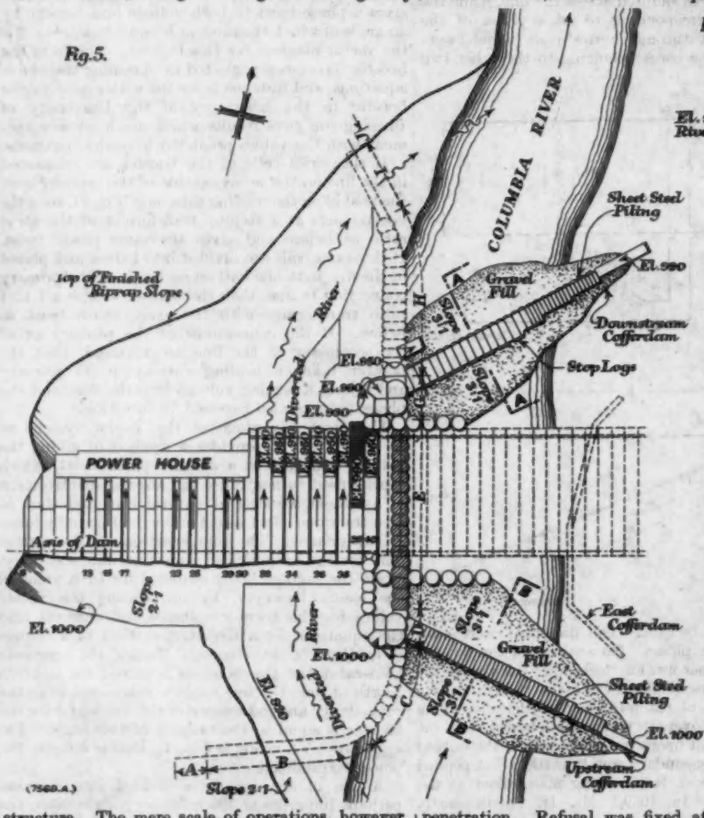


Fig. 6. SECTION AA

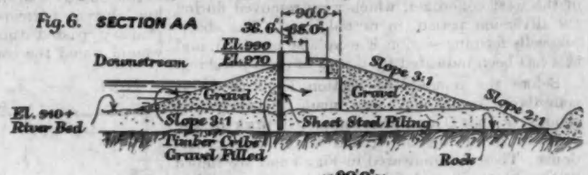


Fig. 7. SECTION BB

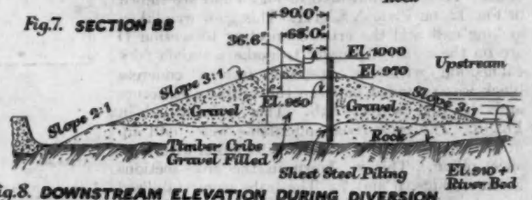
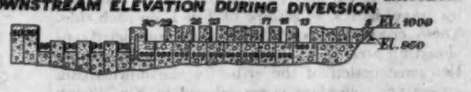


Fig. 8. DOWNSTREAM ELEVATION DURING DIVERSION



west power-station structure and the west end of the spillway. This is shown in Fig. 5. Arrows in this figure indicate the passages which were provided for the passage of the river when it had been diverted by the building of the cross-river cofferdams. The elevations of the various sections of the spillway are indicated in Fig. 5, and Fig. 8 is a downstream elevation showing the water passages provided during the diversion period. Four of the blocks were built up only to elevation 910, level with the bottom of the river channel. The three intervening blocks were 40 ft. higher. This gave a low section 350 ft. long to provide a diversion channel. To prevent serious eddies and erosion in the tail way, additional gaps, aggregating 225 ft. in width, were left at elevation 950 in the power-house section.

In describing the construction of the west cofferdam, it was mentioned that the clusters of cellular piling, indicated at D and G in Fig. 5, formed part of both the west cofferdam and the cross-river cofferdams. This will be clear from the figure, in which the procedure adopted has been made more easy to understand by showing the outlying portions of the west cofferdam, which were removed during the diversion period, in dotted lines. The sheet-pile cells forming section E were also removed, and this has been indicated by means of cross-hatching.

Before the removal of Section E of the west cofferdam, connection was made between cell groups G and D and the completed work of the spillway by means of circular timber-crib cofferdams. These are indicated in Fig. 5 and are shown in Fig. 12, on Plate XXXIII. This view was taken looking east and the cribs connecting to section D are on the right. In order to make a satisfactory connection with the upstream face a concrete block was provided between the spillway structure and the first timber crib. This is indicated in Fig. 5. The cross-river cofferdams were built up of heavy gravel-filled timber cribs faced with steel sheet-piling. This is shown in the cross-sections given in Figs. 6 and 7. The cribs were stabilised by gravel banks, at a slope of 3 in 1, on each side. These cross-river cofferdams when completed enclosed an area of 55 acres. A photograph showing the construction of the cribs for the downstream cross-river cofferdam is reproduced in Fig. 13, on page 410. The east-side cofferdam can be seen in the background in this illustration, and a portion of the cells of the west cofferdam in the foreground.

The downstream cofferdam was first built, and in order to provide additional free passage for the river for as long as possible, the first 448 ft. of this cofferdam, adjacent to section G, was formed from timber cribs of U-shaped cross-section. The cribs were 90 ft. by 64 ft. in plan, the 90-ft. dimension lying roughly parallel to the stream flow. The U-shaped cribs provided a series of troughs through which a large proportion of the river passed. At low water there was a head of only a few feet between the upstream and downstream sides of the cribs. When all the cribs had been secured in position, the U-shaped openings were gradually closed by stop logs, consisting of 12 in. by 18 in. timbers, 32 ft. long, which were dropped into vertical guides provided at the upstream face of each crib. The width of each opening was approximately equal to half the width of a crib, so that half the cofferdam length of 448 ft. was free for the passage of water during the constructional stage.

The bases of the cribs, below the U-shaped openings, were 15 ft. high, and in them pockets were provided which were loaded with rock ballast to hold the cribs in position. They were finally secured, after the stop-logs had been inserted, by driving a row of steel sheet-piling along the downstream face. When this work had been completed, tie-beams, consisting of double 16 in. by 24 in. timbers, were secured on top, spanning the U-shaped openings and forming two roadways along the crest of the cofferdam. On these, dump trucks, operating from the shore end, were used to deposit spoil at each end of the cofferdam, as shown in Figs. 6 and 7. After the downstream arm had been constructed in this way, the upstream arm was proceeded with. Owing to the protection provided by the downstream arm, this could be built in relatively slack water. As already mentioned, the west cofferdam contained 13,000 tons of steel sheet-piling. The total weight of material of this class used in the whole cofferdam system was 18,000 tons. In addition, 2,800 tons of miscellaneous steel were used, and 18,500,000 ft. of timber. The amount of excavation for the cofferdams was 1,328,735 cub. yds. and 1,502,000 cub. yds. of spoil were used for filling.

(To be continued.)

THE USE OF THE QUADRATURE BOOSTER FOR LONG DISTANCE POWER TRANSMISSION.

By E. J. KIPPS, M.Sc., M.I.E.E.

AN article by Major A. M. Taylor, which was published in ENGINEERING some four years ago,* contained diagrams showing a three-phase core-type quadrature booster. The star-connected primary of this booster was shunted across the line, while the line current corresponding to each phase of the primary passed through series coils which were wound round the cores belonging to the other two

Fig. 1.

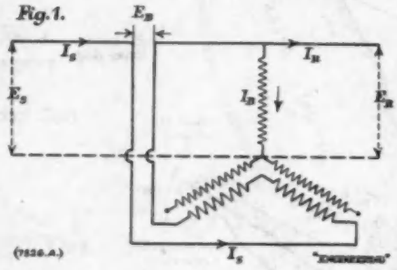
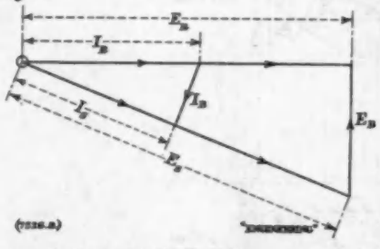


Fig. 2.



phases of the booster. The diagrams were substantially single phase. No analysis of the booster was given, neither was any method of calculating the efficacy of any particular set of boosters in cancelling out the effects of reactance and capacitance along the line. Moreover, it was not explained why the best condition of operation under which the output of the booster secondary was "wattless" depended upon unity power factor being maintained at the receiver load. In 1939,† Mr. H. Rissik partly remedied these omissions, though his article primarily discussed the suitability of the booster for dealing with the values of the reactance voltages and capacitance currents which exist in standard transmission lines and the methods of maintaining a specified voltage at the receiving end. The present article deals particularly with the use of the quadrature booster for injecting an electromotive force into the line to neutralise the voltage drop due to line reactance and for taking a lagging current from the line to balance the leading current due to line capacitance.

In a transmission line which is supplying a load at unity power factor there is a certain value of voltage and current at the receiving end which will give the same phase angle between the voltages at the sending and receiving ends as between the currents at these points. This is the "natural" load of that transmission system and the "system angle," that is, the phase angle between the voltages or the currents at its ends, is then equal to the hyperbolic "line angle." The voltage and current are uniform and in phase at all points on the line. The stability of operation of the line is affected by the "system angle" and the Taylor system may be described as a method of neutralising this influence, thus obtaining the effect of a line without either capacitance or inductive reactance.

Fig. 1 is a diagram of a Taylor booster and allows the following equations to be deduced :—

Vector values.—

$$\hat{E}_S = \hat{E}_R(1 - jk); \quad \hat{I}_S = \frac{\hat{I}_R}{(1 + jk)};$$

$$\hat{E}_R = jk\,\hat{E}_R; \quad \hat{I}_R = -jk\,\hat{I}_S.$$

R.M.S. values.—

$$E_S = E_R\sqrt{1 + k^2}; \quad I_S = \frac{I_R}{\sqrt{1 + k^2}};$$

$$k = \frac{\sqrt{3} \times \text{(secondary turns on one core)}}{\text{(primary turns on one core)}}.$$

From these equations it will be seen that the booster acts as a step-down transformer and also gives a phase twist to both voltage and current by an angle of which the tangent is equal to k. Fig. 2 is the vector diagram for this booster. Losses in the booster have been neglected in obtaining the above equations, and tests made by the writer on a Taylor booster in the laboratory of the University of Birmingham gave results which are in close agreement with the values predicted from the equations.

If the series coils of the booster are connected in the line on the receiving side of the primary coils (instead of on the sending side, as in Fig. 1), then the booster acts as a step-up transformer of the same ratio as before and gives the same phase twist. If the series coils are divided into halves and placed in the line with one half on each side of the primary connection to line, then the booster acts as a 1 to 1 ratio transformer with the same phase twist as before. If the connections of the primary or of the secondary to the line are reversed, then the booster takes a leading current in its primary and injects a lagging voltage into the line, and the phase twist is also reversed in direction.

The chief advantage of the Taylor system is, therefore, that it provides a method of giving the voltage and current a definite phase twist, which can be used to neutralise the angular displacement of a system working at natural load and thus to give the same effect as if the line had no inductance or capacitance. The compensation will be correct only for the natural load condition and will necessitate the voltage being adjusted for each value of the load. However, by introducing the vector values for the booster voltages and currents into the equations for a circuit, the effect of a change of load can be investigated. To find the aggregate kVA-rating of the boosters required for a given length of line, the line angle is calculated from the capacitance and inductance of the line and k for the booster is equal to the tangent of this angle. The aggregate kVA-rating is $k\,E_R\,I_R$, that is k times the power transmitted.

A line of any length is divided into sections, perhaps 100 miles or 125 miles for each section, and each section is equipped with a booster to neutralise the system angle. By this method the distance over which power can be transmitted economically is determined by capital cost only, as it overcomes the technical difficulties which limit the distance of transmission by other methods. In view of the fact that a method has been found whereby the capacitance current of the line becomes, within limits, a positive advantage, it now becomes possible to raise the voltage of transmission without being embarrassed by the increased capacitance current, and thus to be in a position to transmit much greater powers with less copper per kilowatt. The stability is also greatly improved by the employment of a higher voltage.

* See ENGINEERING, vol. 143, page 311, *et seq.* (1937).
† See ENGINEERING, vol. 147, page 33, *et seq.* (1939).

FERODO PRODUCTS.—Messrs. Ferodo, Limited, Chapel-en-le-Frith, Stockport, have sent us a copy of the 1941 supplement to their No. 745 catalogue. This gives particulars of the types, dimensions and prices of their brake and clutch linings for touring cars, commercial vehicles and motor cycles, and of Ferogrip fan belts, flat belts and other products.

GRAND COULEE DAM ON THE COLUMBIA RIVER, WASHINGTON, U.S.A.

(*For Description, see Page* 401.)

FIG. 9. TRAVELLING CONVEYOR LOADING COFFERDAM CELLS WITH SPOIL.

FIG. 10. SPILLWAY CONSTRUCTION IN PROGRESS INSIDE WEST COFFERDAM.

(*Between pages* 402 *and* 403.)

UNIV. OF MICH.

GRAND COULEE DAM ON THE COLUMBIA RIVER, WASHINGTON, U.S.A.

(*For Description, see Page* 401).

Fig. 11. Work in Progress inside East Cofferdam.

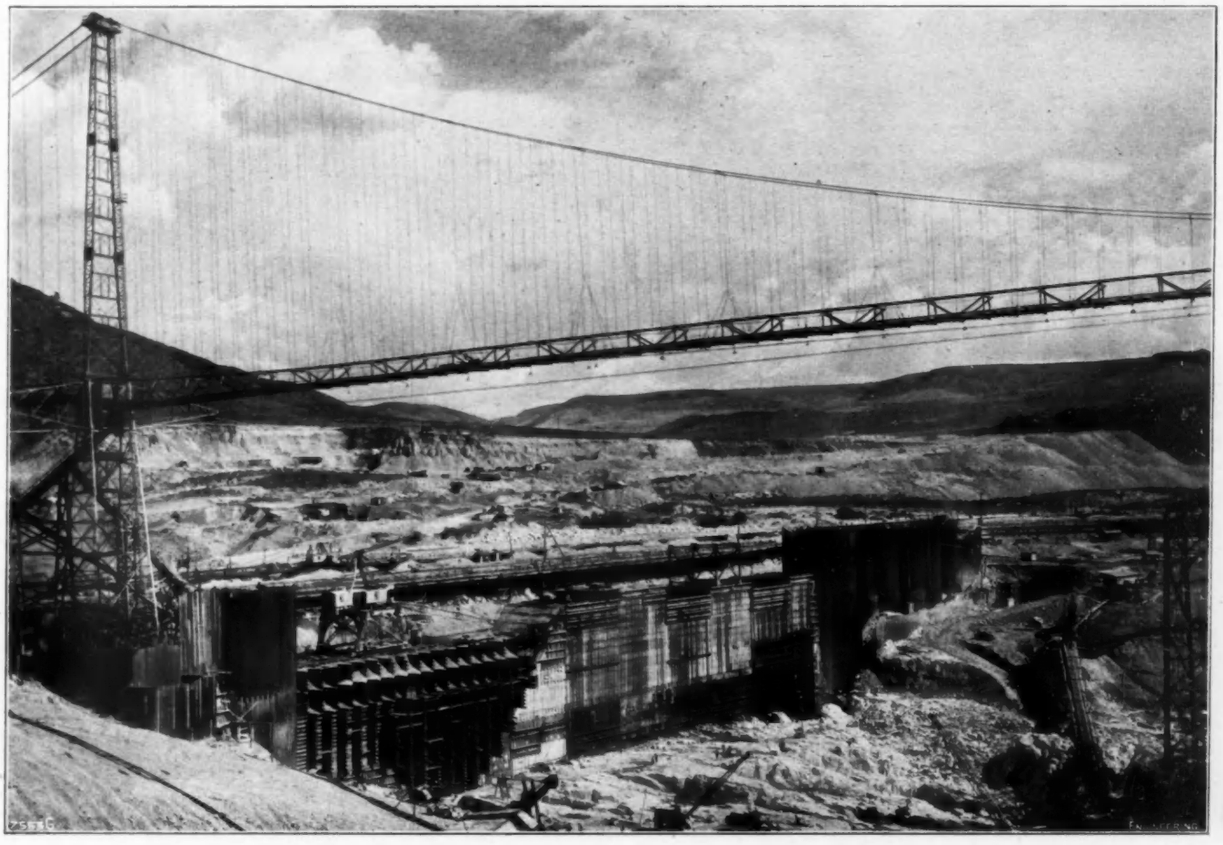


Fig. 12. Timber Cribs Connecting Dam Structure to Sheet-Pile Clusters.

(*Between pages* 402 *and* 403.)

UNIV. OF MICH.

INCENTIVES FOR FOREMEN.

By F. J. BURNS MORTON.

THE war is placing ever-increasing responsibilities on works foremen. New problems arise every day; the enlistment, retention and adjustment of labour call for new methods and extra effort; new technical tests are set by the increasing variety of war requirements. Much of this work falls on the shoulders of the relatively decreasing numbers of supervisory staff, already strained by the loss of persons in key positions. The situation is made doubly onerous by the fact that so many operatives have received greatly increased remuneration owing to the provision for cost of living increases, rising rates of wages due to labour scarcity, and the greater volume of work available. Not unnaturally, dissatisfaction is felt by foremen when the men under their supervision are receiving regularly higher wages than their own.

Business directors favour in theory the payment of supervisors according to results. The need for an incentive which rewards automatically according to efforts, and which avoids periodic and permanent increases in salary, is generally recognised. The chief obstacle to the wider adoption of supervisory incentives is the difficulty of finding a satisfactory basis. It is necessary to have a definite link between results and rewards; and the results must be traceable to supervisory effort rather than to improvements in trade, changes in policy, internal reorganisation, and the like. When both external and internal changes affect supervisory earnings, there is some reluctance to alter the basis of bonus computation, so that in time the incentive may get completely out of hand. It is necessary to prevent commitments entered into in good faith in prosperous times becoming untenable in poor times. On the other hand, workpeople are likely to complain that a supervisory incentive results in excessive speeding up for the foreman's personal gain. In trades such as quarrying or mining, an incentive for foremen has been blamed for accidents. Yet, in spite of these difficulties and criticisms, which, from time to time, have been levelled against piecework in general, it is often thought desirable to offer some financial incentive to the supervisory staff.

The general conditions to be considered in formulating a scheme for such an incentive may be summarised as follows:—(1) The scheme should be definite, should not be subject to constant variations and adjustments, and should be guaranteed for at least a year ahead; (2) the basis should be straightforward and easily understood, and clearly set out in writing; (3) it should be founded on past results and future possibilities, and a definite relation should exist between savings and rewards; (4) the results should reflect as nearly as possible the work involved; (5) bonus earnings should be paid in good faith, irrespective of the amount and original intention; (6) it should reward the participant individually, if possible, and according to his contribution, and be confined to results over which he has a large measure of control, any other factors being standardised; (7) the basis should be sufficiently wide to ensure general benefits to the company and should avoid any incentive to advance certain interests at the expense of others, *i.e.*, it should encourage co-ordination; (8) bonus earnings should begin only after standard results have been achieved, so as to reward the improvements effected; (9) the bonus should bear some relation to the grade of responsibility; (10) the methods of achieving results should be set out, giving guidance and encouragement towards higher earnings; (11) bonus should be paid frequently, either monthly or quarterly, and in separate envelopes. Relevant figures of results should be supplied and helpful comment given.

Incentive payments for foremen fall into two classes, namely, group and individual. Both arrangements have their advantages, depending on the purpose that the incentive is to serve. The group incentive stimulates collaboration, tends to break down watertight compartments, and encourages inter-departmental transfers of staff. There is a greater willingness to make departmental adjustments to fit in with the general plan. The group incentive is usually based on profits or production.

Profit Sharing.—Many companies prefer profit sharing as a basis of bonus distribution to its senior executives and supervisory staff, because it links up the fortunes of the individual with the prosperity of the company. As against its disadvantages, which may be said to be chiefly in restricting bonus payments to times of prosperity, there is the contention that the greatest effort and the most rigid economy are required when profits are not so plentiful. Wise policy and good direction might contribute more to profits than managerial or supervisory effort, in which case bonus payment is not a proportional award for increased endeavour. On the other hand, the striving of foremen to make profits might well be thrown away as the result of unwise policy or managerial ineptitude; and, in any case, they depend in a large measure on market conditions. For the earnings of foremen to depend on such factors as these savours of a gamble.

In order that the bonus should be earned intelligently, all relevant information should be provided. This means disclosing not only particulars of profits, but also details of income and expenditure. It stands to reason that, unless the foreman has a fairly clear conception of how profits are made and lost, he cannot be expected to regard a bonus as other than a gift, calculated in a manner he is quite unable to understand. Most firms would seriously object to their accounts being inspected by foremen. Apart from this aspect, there is the question of inviting criticism of expenditure and policies, which are not the foremen's concern. There is another serious objection to profit sharing; if bonus payments are to be made either yearly or half yearly, the period is too long to maintain interest at its highest peak and provide that constant stimulation which comes from more frequent awards. Payment should follow as soon as possible after the effort which it rewards.

Production Measured by Turnover.—To overcome the objections to a bonus based on profits, a group incentive may be provided on production performance measured by turnover. By this means, many fluctuating expense items, such as sales, prices of materials, and wage rates, which cannot altogether be controlled by foremen, are excluded. Production measured by turnover provides an accurate record which cannot be disputed, as it is compiled by accountants and not by works staff. Generally, turnover in cash is to be preferred to output in orders; it correctly takes into account the varying sizes of orders or products, and if the labour cost percentage is similar for the products manufactured, reflects fairly accurately the amount of work done. Where the purpose of the incentive is to obtain production, turnover provides many advantages for a group incentive to foremen.

The chief objection to an exclusive emphasis on production is that the results might be obtained by uneconomic employment of men, materials, and machines; for example, by inducing the foreman to employ expensive labour and to work excessive overtime. In fact, an incentive on turnover completely disregards costs. These objections could be overcome by a vigorous general management, but it should be borne in mind that a supervisory bonus is intended to lighten the burden of management, not to make it heavier. If an incentive needs continuous correctives, it loses its effect. Where the cost of labour and materials can be standardised and controlled without additional expense, considerable gain might be secured by greater production, and the savings on overhead expenses could be partly employed to reward the foremen.

Another disadvantage of turnover as a measure of production is that changing prices are likely to cause an automatic change in turnover, with a corresponding effect on bonus. Adjustments can be made in the basis of the bonus payment to accommodate fluctuations in price, but frequent modifications of this kind are not advisable. With all incentives, consideration must be given to the effect of changes over which the participants in the reward have no control. Turnover may be greatly increased by the erection of new buildings and the installation of additional plant, the introduction of modern machinery and labour-saving devices, the simplification of system, new inventions and designs, or improved lay-out.

An incentive for individual results is often to be preferred to group sharing of rewards, as it rewards each person according to his own efforts. The common complaint against group sharing schemes is that earnings made by those above the average are shared with those below the average. An incentive is employed to obtain that greater effort and drive which makes all the difference between doing a job and doing it well, and it is often contended that better results accrue from individual reward than from group sharing. For the purpose of individual or departmental incentives a number of alternatives present themselves.

Cost Reduction.—Lower costs contribute materially towards higher profits and a person achieving this result may be rewarded by a share in the results obtained. Three kinds of costs usually form the basis of an incentive for savings, namely, direct labour costs, material costs and indirect costs. Depending on circumstances, an incentive might be provided for any one of these, or any combination of them. Once the basis has been declared, the problem of the foreman is made clear, in that he must economise in materials, labour and overhead expenses. If one item of cost, such as labour, is singled out for special reward, care must be taken to avoid results in this direction at the expense of some other, such as material cost. An incentive on general cost reduction is to be preferred to avoid this possibility. Here, again, difficulties arise in practice due to changes in market conditions, over which the foreman has no control. Rises in the rates of wages or the prices of raw materials might be allowed for, but adjustments are liable to be regarded as unfair. An incentive is a delicate instrument which may easily do harm if enthusiasm changes to dissatisfaction. The basis of the incentive must be sound if it is to do its work properly. If its working or adjustment introduces any suspicion of injustice, results might be better if it had never been introduced. For this reason an incentive should be constructed to continue for some substantial period of time, not less than one year.

Increased Output.—Where essential labour and material cost have been standardised and do not offer great possibilities of reduction, an individual incentive can be introduced with departmental output as its object. Where departments form a sequence of operations, it is not possible to express the contribution of each in items of cash turnover, and it is more common to express output by units or weights. This is a satisfactory measure where the work is confined to one product or to products which do not vary to a great extent. Where there is a wide variety of work, it is sometimes possible to weight the different classes to obtain a comparable indication of production. Unfortunately, output figures are often compiled departmentally and are not so reliable as those of turnover, which must be reconciled with the general accounts. Another method is to pay the foreman the average bonus earnings of his department, where the operatives themselves are paid on an incentive basis. One of the chief objections to an incentive based on departmental output is the same as that cited against production measured by turnover: results are dependent on a more or less unlimited supply of work. Departmental output is not only dependent on this general supply of work, but also on the supply from preceding departments and on the capacity of acceptance of those following.

Better Quality and Other Incentives.—A financial incentive to foremen is a legitimate means of correcting any outstanding weaknesses which cannot easily be cured by other means. Quality of workmanship is one of the main aspects of production to suffer when greater output is demanded. In many industries, quality is more important than increased output, especially where the cost of raw materials is high and where work not up to standard means sheer waste. Quality can be measured in many ways. The proportion of rejects is perhaps the most common. Where quality cannot easily be measured in this way, the number of complaints, the amount of customer compensations, or the cost of servicing and repairing manufactured articles not satisfactory after sale can be taken as fairly

sound indexes of quality or lack of quality. Where firms operate under intensive competition, customers' dissatisfaction means lost trade and a loss of goodwill. Sometimes this aspect may be singled out for a special incentive, but, at the same time, there must be some definite link with costs of production and extent of output. Other incentives may be constructed to deal with special problems in a trade, a firm or a department, for example, the question of labour turnover. The foreman's influence in this direction is greater than is usually supposed, and in times of severe labour shortage it is important to place a brake on supervisors who are unable to retain staff.

Strictly speaking, an incentive should be a reward for improvements upon existing or standard results. Unless wages are unduly low and some form of compensation is necessary, bonus should not be paid on results already being obtained, or for improvements already in hand or contemplated. Provision should also be made for changes which improve results, but not directly due to the participants' efforts. In any case, the incentive should be made effective by offering rewards that are worth having. It is not possible to set down definite rules or percentages, as circumstances vary considerably, but it may be suggested, as a general guide, that the reward for increased profits or definite saving attributable to the foremen should vary from 1 per cent. to 10 per cent., depending on the possibilities for improvements. Naturally, where the management is satisfied that further improvements are difficult to secure, the reward should be on a correspondingly higher level. It should, of course, bear some relation to the wages earned, and it is commonly considered that such a bonus should amount to between 10 per cent. and 30 per cent. of the basic wages. It is sometimes argued that bonus possibilities should be unlimited and that very high earnings should be met cheerfully; but practice indicates that, while excessive bonus might be paid for occasional and exceptional results, it will not long be tolerated. If the circumstances are ripe for a supervisory incentive, and the incentive is well constructed, such conditions will not arise in practice.

In connection with group incentives, the method of distribution is important. Some definite arrangement is necessary; it cannot be arbitrary. Two alternatives are available: either to share the bonus fund equally between the participants or to distribute the fund on the basis of existing salary. In favour of the first principle, it may be said that existing wages should take care of the difference in responsibility and capacity, so that the increased earnings of the group should be shared equally. With the alternative of a proportionate distribution, it is sometimes contended that the participants contribute to the improved position according to their ability, which may be measured by their basic earnings. In general, proportionate distribution is more likely to give rise to friction and discontent than an equal sharing out of the available fund.

The results to be expected from incentives depend on how they are presented, their soundness, and what they seek to achieve. The benefits generally expected and obtained can be briefly summarised by saying that the incentive inspires greater interest among foremen; secures higher output, reduced operating costs in labour and material, greater speed of production and better service, and better quality of workmanship; minimises labour turnover and improves working conditions; induces a better reception of improvements and suggestions; and promotes closer co-operation between management and men. If it is possible, by offering a financial reward for results, to make the foreman regard his department as a business within a business, to focus his attention on the essentials of profit making, and to appreciate the value of proper planning, adequate training, staff stimulation, and co-ordination of effort, the standard of supervision and the fortunes of the concern are bound to be improved thereby. The incentive is a reward for savings, for greater output, or for better quality. Its successful application depends on its soundness, on avoiding pitfalls, on providing ahead for eventualities, and on instituting a definite relation between savings and rewards.

THE LACEY THEORY OF RIVER STABILITY.

IN two remarkable and now classic papers to the Institution of Civil Engineers,* Mr. Gerald Lacey, of the Public Works Department, Irrigation Branch, United Provinces, India, developed an analysis of data relating to rivers in incoherent alluvium. He has now produced a valuable report†, which supports and summarises his conclusions in a complete and broad manner, and will be of great interest to all engineers concerned with rivers, and also to physical geographers.

The central feature of Lacey's work is the establishment of a regime formula, independent of silt grade, as follows:—

$$V_r = 16\,R^{\frac{2}{3}}\,S^{\frac{1}{3}} \quad . \quad . \quad . \quad (1)$$

where V_r is regime velocity in feet per second; R the hydraulic radius in feet; and S the slope; or, in absolute terms

$$4\,(2g)^{\frac{1}{2}}\,R^{\frac{2}{3}}\,S^{\frac{1}{3}}. \quad . \quad . \quad . \quad (1A)$$

If the flow velocity V, according to any of the usual forms, and the regime velocity according to formula (1) are drawn on a basis of the product R S, as shown in Fig. 1, herewith, the two curves inter-

Fig. 1.

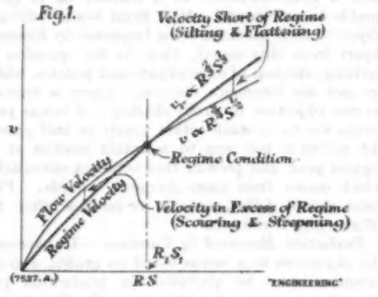
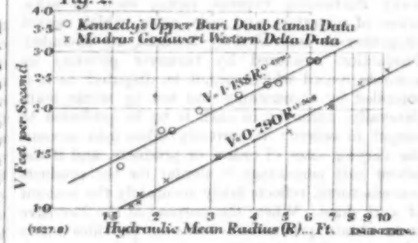


Fig. 2.



sect at a value $R_1 S_1$. On the left of this value, actual flow velocities exceed regime values, so that alluvium tends to scour or the slopes to steepen. On the right side, actual velocities are less than regime values, so that the bed tends to accrete or the slope will flatten.

For a reason which is explained later, Lacey accepts as practically proven a flow formula

$$V = \frac{1{\cdot}3458}{N}\,R^{\frac{2}{3}}\,S^{\frac{1}{2}}. \quad . \quad . \quad (2)$$

N being the rugosity coefficient equal to Kutter's when R is 1 m. (3·28 ft.); or, in absolute terms (metre, kilogram, second),

$$V = \frac{1}{N}\,.\,R^{\frac{2}{3}}\,S^{\frac{1}{2}}. \quad . \quad . \quad . \quad (2A)$$

This, of course, is one of the many forms of the Manning formula, and is, in fact, that used by Professor Lea.

The possibility of regime conditions in rivers or canals, where there is neither silting nor scouring, is a practical fact. Just what combination of grain size, water velocity, channel dimensions or stream slope determines these conditions, however, has not been known. The earliest and most famous attempt to define regime conditions is the Kennedy formula of 1895:—

$$V_r = c\,m\,D^n \quad . \quad . \quad . \quad (3)$$

where V_r is the critical mean velocity in feet per second; m is a ratio depending on the grain size; c is a coefficient reputed to be about 0·84; D is the central depth in feet of a trapezoidal canal water section; and n is an index, reputedly about 0·64.

In 1923, Lacey re-analysed the data which had been used by Kennedy, together with other figures which had been obtained by observers elsewhere, and showed that they were all consistent with a form

$$V_r = c\,R^{\frac{1}{2}}. \quad . \quad . \quad . \quad (4)$$

where c depends on the silt grade. This he now writes as

$$V_r = K\sqrt{f\,R} \quad . \quad . \quad . \quad (4A)$$

where $f = \left(\frac{N}{N_0}\right)^4$; $K = \left(\frac{4}{3}\right)^{\frac{1}{2}}$ (foot units); and N_0 is a standard value of 0·0225.

If the slope is eliminated from equations (1A) and (2A), by writing, in regime conditions,

$$V = \frac{R^{\frac{2}{3}}\,S^{\frac{1}{2}}}{N} = V_r = 4\,(2\,g)^{\frac{1}{2}}\,R^{\frac{2}{3}}\,S^{\frac{1}{2}}$$

the result is obtained,

$$V_r = 64\,(2\,g)\,N^2\sqrt{R} \quad . \quad . \quad . \quad (4B)$$

The fact that this is dimensionally the same as (4A), which latter he considers to be established by observations, confirms equation (2) or (2A) as a good flow equation. Fig. 2, herewith, shows his demonstration of formula (4), and Fig. 3, on the opposite page, shows his demonstration of his fundamental formula (1).

One slight criticism that suggests itself is in regard to the values of N in formulæ (2) and (4B). The values of N have always tended to be somewhat arbitrary. The endorsement which he gives to the flow formula (2) is dependent on a real constancy of N for the particular material. The "spread" of the points in Fig. 3 is pertinent in this connection.

From a comparison of deduced values of N with grain size he gives an equation

$$\frac{N}{N_0} = (1{\cdot}76)^{\frac{1}{6}}\,m_1^{\frac{1}{6}}. \quad . \quad . \quad . \quad (5)$$

where m_1 is the diameter of the grain in millimetres. It seems rather improbable that mere grain size can fully determine rugosity, without any reference to grain shape and sharpness, but, of course, average conditions are presumed.

From the above equations, it follows that there may be deduced a regime value of the slope

$$S = \frac{(2\,g)^2\,(64)^2\,N^6}{R^{\frac{1}{3}}} = \frac{V_r^2}{64\,(2\,g)\,R^2}\ \text{(metric units)} \quad (6)$$

but, as he points out, this value is only true for straight uniform reaches; and irregularities of section and of alignment may almost double the slope, or, if neglected, may lead to inconsistent values of N.

Still another very sweeping generalisation, deriving ultimately from Lindley's work in 1919, is that the wetted perimeter (almost the same as the width, for shallow streams) varies as the square root of the discharge. In foot units, he gives the expression

$$P = 2\tfrac{2}{3}\sqrt{Q} \quad . \quad . \quad . \quad (7)$$

and substantiates it by Fig. 4, opposite.

Twenty-four tables of data are given in the text and appendices of the report in support of his conclusions, together with twelve diagrams and a very full index.

In the last chapter, he compares his formulæ with those derivable from a dimensional analysis and endeavours to include shock and viscosity factors, and remarks:—"In conclusion, the writer would emphasise that his theory in its initial stages was evolved as a solution to a practical problem, the design of silt transporting channels that would neither silt nor scour. He was faced also with a tradition that involved the use of two very intractable empirical equations, the Kutter and Kennedy, respectively. The simplification which immediately resulted from a recours eto exponential flow equa-

* "Stable Channels in Alluvium," *Proc. Inst. C.E.*, vol. 229, page 259 (1930); and "Uniform Flow in Alluvial Rivers and Canals," *Proc. Inst. C.E.*, vol. 237, page 421 (1934).

† *A Regime Flow in Incoherent Alluvium.* Simla 1939. Central Board of Irrigation, Publication No. 20.

LACEY THEORY OF RIVER STABILITY.

Fig. 3.

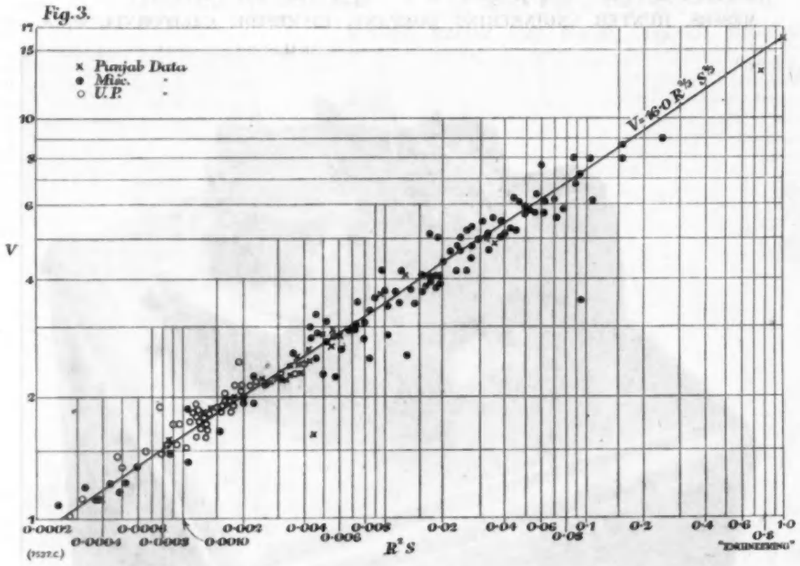
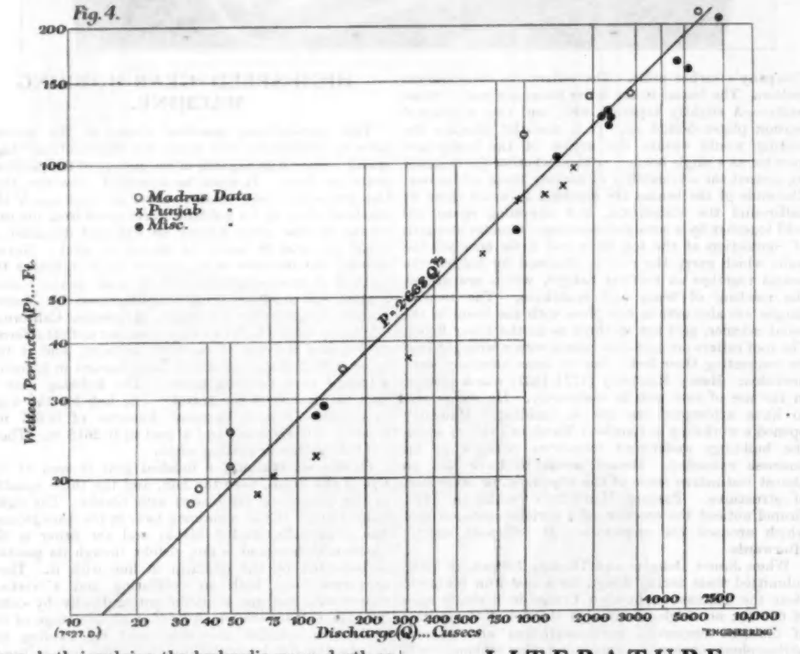


Fig. 4.



tions, both involving the hydraulic mean depth as a variable, made possible a mass of derived equations, rapidly expanded the field of investigation, and with that expansion multiplied points of contact with the unknown. For this reason it has not been possible to present the theory with the simplicity and lucidity that a laboratory experiment would demand. The problem is far from simple and still awaits a complete solution."

It is rather unfortunate that he uses the symbol *m* with two meanings, one a velocity ratio and the other the diameter of grains, but the latter only occurs in a subordinate reference. It is worth remarking that the credit for a general conception of regime, as applicable to widths and depths, rests with Lindley and J. M. Lacey.* The recent applications in America and elsewhere of the old Du Boys theory of constant tractive resistance at the bed are also pertinent.†

* Gerald Lacey, *loc. cit.*, page 3, J. M. Lacey, *Min. Proc. Inst. C.E.*, vol. 216, page 151 (1923).

† "Stable Sectional Form of Alluvial Rivers," by Dr. H. Chatley, ENGINEERING, vol. 146, page 740 (1938).

LITERATURE.

Cement Chemists' and Works Managers' Handbook. By W. WATSON, B.Sc., and Q. L. CRADDOCK, M.Sc. London: Concrete Publications, Limited. [Price 15s. net.]

THE technical control of a Portland-cement factory has two distinct sides, the engineering and the chemical, of which the latter is the more standardised. It is to this side more particularly that the authors of the present work have directed their attention. The title of the book, however, must not be interpreted too widely. The problems of crushing, grinding, drying, conveying, packing, etc., which occupy much of a works manager's time, are not included, but the chemical side, as roughly defined herein, is treated more completely.

Section I contains very complete summaries in tabular form of national cement specifications of thirty-three countries, together with tables of the standard sieves in normal use. Section III contains tabulated unit weights and volumes of slurries of varying water content and ignition loss; and Section V gives gas volumes and velocities in relation to kiln output, based on standard slurry and coal conditions, and covering the complete range of variation likely to be found in practice. The long series of tables of gas velocities are based upon a table of assumed outputs of kilns. In practice, there may be considerable variations from these values, so that, in using the tables, two subsidiary corrections for temperature and output may be required. As velocities can be obtained from the volume table by a simple slide-rule operation, the velocity tables are more useful as a check than for direct use, except as an approximation.

The fundamental assumptions of Section V are used in the tables of Section VII. These give weights, volumes and densities of excess air and kiln exit-gases over the practical range of coal consumption and temperature. This section is followed by one giving corresponding data on the constituent gases of the kiln discharge, so that all necessary calculations from any gas analysis may be made readily. Proportioning and control of raw mixes is treated in a section which includes descriptions of standard methods of calcium-carbonate determination. Only Lea and Porter's formula is used for proportioning. The authors point out that no hard and fast formula can be evolved to suit all cases; but this makes reference desirable to other formulæ in use in order to give a clearer idea of the extent of variation. The section on kiln heat balances sets out admirably the practical factors which make up this important feature of control, reducing the results of research to a statement of direct utility by reconciling divergences and setting out ways of computation which eliminate uncertainties that might arise in working from the research records. The purely chemical aspects have not been treated in the detail that might have been expected. They are covered by three sections on standard reagents, chemical tables and the analysis of raw materials and cement. In the last-mentioned section, the standard routine works analyses are briefly described. It is preceded by one containing conversion tables for obtaining constituent percentages directly from weights of precipitates.

The authors have made accessible in a convenient form much information that has had to be obtained hitherto from diverse sources. The tabulation of the data has been done very thoroughly. The clarity with which, immediately before the tables, the assumptions made and the numerical constants used in their compilation are set out is a valuable feature. By knowing exactly the basis of computation the user is able to assess the value of the results and thus, also, the reliability and accuracy of his own calculations and conclusions. Some of the sections could have been enlarged with benefit. A surprising point is the total omission of any reference to gas analysis, all the more so as the information about kiln gases is so full. Of the engineering features, only combustion is dealt with, but this is treated very completely. The book should be of considerable value to those concerned with the design and operation of cement plants, and, the higher the standard of works efficiency, the more useful it is likely to be.

MINING EXAMINATIONS.—The Secretary for Mines has given notice that, by the Coal Mines (Mining Examinations and Certificates of Competency) Order, 1941 (S.R. & O. 1941, No. 635), Section 9 of the Coal Mines Act, 1911, has been temporarily amended. The qualifications required of applicants for first and second-class Certificates of Competency have been changed by providing that candidates who are within six months of the normal age limit shall be allowed to sit for the examinations, subject to certain conditions. Details of this arrangement were set out in M.D. Circular No. 130, issued on March 27, 1941. A consequential change in the Board's Rules governing these examinations has been effected by the Mining Examinations (Certificates of Competency) Rules, 1941 (S.R. & O. 1941, No. 636), made by the Board for Mining Examinations and approved by the Secretary for Mines. The new arrangement will be operative for the next examinations beginning on July 2. Inquiries should be addressed to the Secretary, Board of Mining Examinations, Block "C," Temporary Office Buildings, Heyhouses-lane, Lytham St. Annes, Lancs.

THE USE OF CAST IRON IN BUILDING.*

By S. B. HAMILTON, M.Sc., A.M.Inst.C.E.

THE period covering the use of cast iron in building is roughly the Nineteenth Century. The material had been used for such purposes as cannon-balls and stove-plates in Germany as far back as the Fourteenth Century. Cannon were first cast of iron in the Fifteenth Century. John Smeaton, about 1755, introduced cast-iron windshafts and gearwheels into windmills. Millwrights and steam-engine builders hesitated for many years to follow his example; but by the end of the Eighteenth Century the beams, pillars and practically all the heavier parts of steam-engines were made of cast iron. The men who built the engines commonly built the mill; and it was no doubt some unknown millwright or iron-founder who first conceived the idea of using cast-iron columns in mill buildings, instead of timber posts or masonry piers. Except for Sir William Fairbairn's classic work *On the Application of Cast and Wrought Iron to Building Purposes* (1854), there is very little literature accessible on this subject. Like most new developments in technology of a century and a half ago, the early examples of cast-iron structures owed nothing to theory, but, as the use of the new material widened, it raised problems which mere empiricism could not solve; and about 1830 the tentative phase ended, and cast-iron construction became a subject of deliberate experiment and scientific study. The culminating period came with the eighteen-fifties, after which a gradual decline set in.

The Tentative Period.—About 1800, the typical textile-mill building consisted of a rectangular block with brick walls, timber plank floors, and beams of square timber baulks, which reached from one side of the building to the other. The span was divided by cast-iron columns, with flat bases and caps. These stood on the beams at one floor, and supported the beams of the floor above. The whole weight of the upper part of the building was carried from one tier of columns to the tier below through the timber beams. No attempt was made in such buildings to make metal to metal contact between the columns of successive storeys. The rigidity of such buildings depended entirely upon the walls; the height to which they could be built was limited by the crushing strength of the timber across the grain. Heavy timber beams and thick planks possess a fairly high degree of fire resistance; but if a fire on a lower floor got out of control the whole structure was doomed, as, once the temperature rose to the point at which the timber gave off imflammable gases, everything in the building except the walls and columns served as fuel. Even though its construction was comparatively expensive, manufacturers began to regard a "fireproof" mill building as well worth a considerable additional outlay. According to Fairbairn, the first building of this kind was erected, in 1801, by Messrs. Boulton, Watt and Company, for Messrs. Philips and Lee, of Manchester. All timber was excluded from the structure, cast iron being introduced as the material for the beams. The beams spanned 14 ft. between cast-iron columns, and brick arches of 9-ft. span were built from beam to beam, to carry stone flag floors, of which there were seven above ground floor, 10 ft. apart.

The modulus of the section of Messrs. Boulton, Watt and Company's cast-iron beams with reference to the tension flange works out at 56 in.^{3}, and with reference to the compression flange, 45 in.^{3}. If dead and super-load combined amounted to 1½ cwt. per square foot of floor, the beam would carry a total load of nearly 10 tons, and be stressed to 3·7 tons per square inch in tension, and 4·7 tons per square inch in compression. As cast iron is about five times as strong in compression as in tension, the material was not efficiently distributed; but this defect was not recognised until Eaton Hodgkinson, in 1830, reduced the results of an exhaustive series of experiments on beams of various shapes to a formula for calculating the strength of a beam. Hodgkinson's formula gives the safe load for this section of beam as 8·32 tons. Fairbairn showed that, by casting the same quantity of metal into the best shape for strength, the carrying capacity of the beam could have been raised to nearly 15·3 tons. Messrs. Boulton, Watt and Company, however, were engineers of high repute; other founders preferred to copy their section without modification for nearly 30 years rather than risk failure by experimenting with new forms. The 14-ft. span and 9-ft. spacing became virtually standard dimensions, presumably because they suited the customary layout o the textile machinery of the period.

A building was erected in Leeds about 1816, it is believed by John Farey, as a flax mill to the order of Thomas Benyon. This building is still known as Benyon's Mill. Its construction appears to show no improvement on that of Messrs. Boulton, Watt and Company's earlier mills. The pillars are of cruciform section. The beams in the lower floors are cast in three parts:—A slightly tapering web, and two additional tension plates bolted on. It is doubtful whether the bolting would ensure the action of the compound member as a single beam; or even whether the designer recognised the advisability of making them act as one. The ends of the beams are moulded to make them fit half-round the stanchions, and adjoining spans are held together by a wrought-iron ring. Greater strength of connection at the top floor and a tie between the walls which carry the roof is obtained by bolting the beams together at vertical flanges, which are not at the meeting of beam and stanchion. The tension flanges are also cast in one piece with the beam in the usual manner, and not in three as in the lower floors. The roof rafters are cast-iron beams with a wrought-iron tie connecting their feet; but no truss members were provided. Henry Maudslay (1771-1831) was a pioneer in the use of cast iron in machinery. He seems also to have attempted its use in building. Maudslay opened a workshop in Lambeth Marsh in 1810, of which the buildings underwent numerous changes as his business extended. Brunel seems to have had an almost instinctive sense of the adequacy, or otherwise, of structures. Passing Maudslay's works in 1826, Brunel noticed the erection of a curious cast-iron roof which aroused his suspicions. It collapsed shortly afterwards.

When James Douglas and Thomas Telford, in 1800, submitted their daring design for a cast-iron bridge to clear the Thames at London Bridge in a single span of 600 ft., no single member of the Select Committee of eminent engineers, mathematicians and natural philosophers chosen to report on the scheme could state the crushing strength of cast iron. Dr. Thomas Young (1773-1829), discussing the evidence given before this Select Committee in the article on "Bridges" which he wrote in 1916 for the supplement to the *Encyclopædia Britannica*, mentioned several simple experiments from which he concluded that the crushing strength of cast iron could safely be taken at a value not less than 50 tons per square inch.

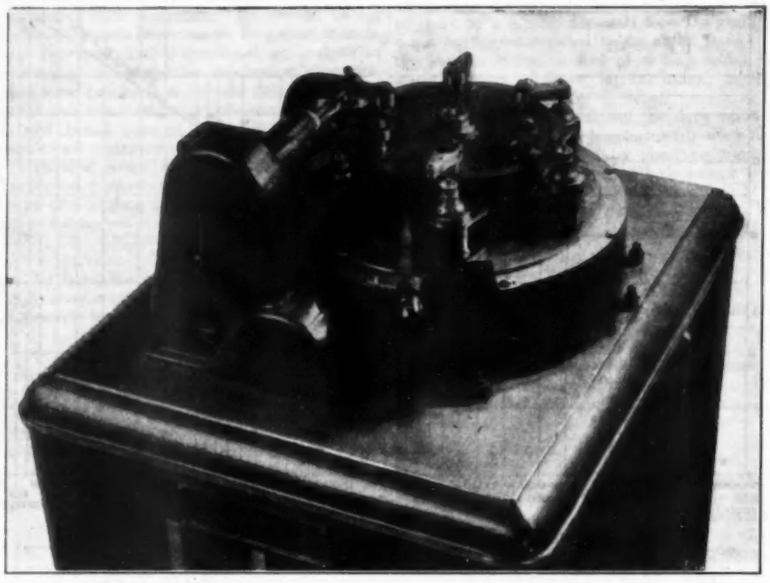
(To be continued.)

* Paper read before the Newcomen Society, in London, on Wednesday, April 23, 1941. Abridged.

THE INSTITUTION OF MINING AND METALLURGY.—The Council of the Institution of Mining and Metallurgy has awarded the Consolidated Gold Fields of South Africa Limited Gold Medal, for 1940, to Mr. Charles Robert Julian, M.C., A.R.S.M., for his paper, "Underground Mining at Rio Tinto, Spain." The Consolidated Gold Fields of South Africa Limited Premium of 40 guineas has been awarded jointly to Mr. Jack Spalding, A.R.S.M., and Mr. T. W. Parker for their paper, "Air-Conditioning Plant at Ooregum Mine, Kolar Gold Field." The William Frecheville Students' Prize of 10 guineas has been awarded jointly to Mr. J. E. Denyer, A.R.S.M., B.Sc., and Mr. K. C. G. Heath, for their paper, "Mining and Milling Tin-Tungsten Ore at Mawchi Mine, Burma."

HIGH-SPEED GEAR-HOBBING MACHINE.

MESSRS. HUNTER ENGINEERING COMPANY, RIVERSIDE, CALIFORNIA, U.S.A.



HIGH-SPEED GEAR-HOBBING MACHINE.

THE gear-hobbing machine shown in the accompanying illustration well merits the qualification "high speed" since it is capable of an output of 960 finished gears per hour. It must be admitted, however, that the gears are only small; thus, as illustrated, the machine is set up for hobbing worm gears from die-cast blanks of zinc alloy having an external diameter of 0·833 in., and 18 teeth, 24 diametral pitch. Nevertheless, the machine is of interest as it indicates the method of producing this class of work in the United States, the machine being manufactured by Messrs. Hunter Engineering Company, Riverside, California. Obviously such a high rate of production as that referred to requires the use of multiple spindles, and it will be seen that there are six of these carried in housings attached to a rotating turret. The hobbing gear is seen to the left of the turret. The hob for the work in question has an external diameter of 0·617 in., a pitch of 0·1309 in., and a lead of 0·2618 in. There are four gashes or cutting edges.

Of the six stations, a finished gear is seen at the left of the drum, near the hob, and the three spindles in the foreground are loaded with blanks. The right-hand spindle of the remaining two, in the background, has a partially loaded blank, and the other is the ejection station and is not visible, though its position is indicated by the overarm in line with it. These overarms have both an oscillating and a vertical movement, and are actuated automatically by cams. The movements are timed so that at any stage of the cycle two spindles are uncovered for loading the blanks, the blank on the spindle at the hob is firmly clamped down, and one spindle is left open for the ejection of the finished work, this ejection being effected by an independent cam. The finished gears are automatically discharged down a chute at the right-hand of the machine, not shown in the illustration, and the operator's work consists, therefore, of loading the machine only. A protecting cover and chute for swarf disposal, again not shown in the illustration, are fitted over the hob and spindle. The machine as shown is arranged for hobbing the blanks without a cutting lubricant, but a supply and return system for this can be readily provided if desired.

The turret does not revolve at a uniform rate. It is clear that, when a cut is being made its rotation must be slow, and also that the blank itself must rotate on its own axis. This is effected by a worm wheel at the lower end of each spindle. Just before a blank reaches the hob, this wheel is caused to engage with a worm driven, through a gear train, from the hob shaft, so synchronising the blank and hob movements. In between cuts the turret is rotated rapidly. The change in turret speed is effected by a limit switch, which actuates a two-way electric clutch. One position of the switch and clutch couples the turret to a low-speed countershaft for slow motion through

HIGH-PRESSURE TWO-STAGE AIR-COOLED AIR COMPRESSOR.

MESSRS. BROOM AND WADE, LIMITED, HIGH WYCOMBE.

Fig. 1.

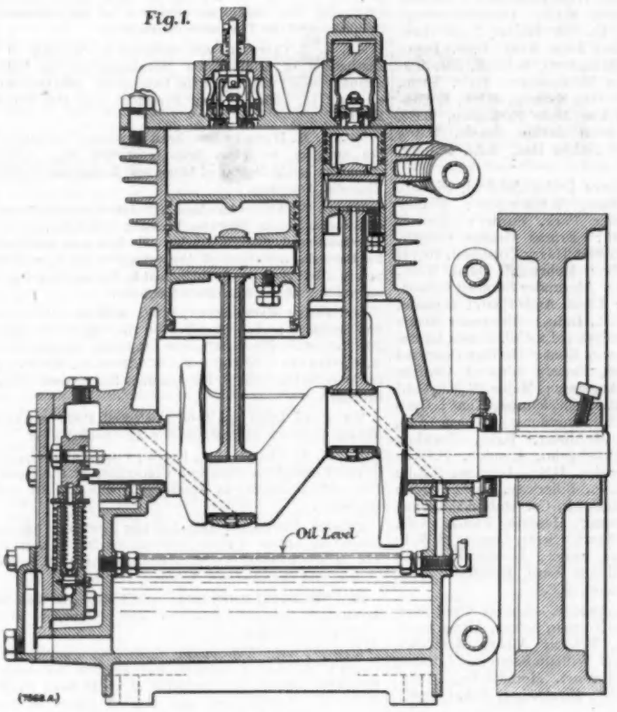
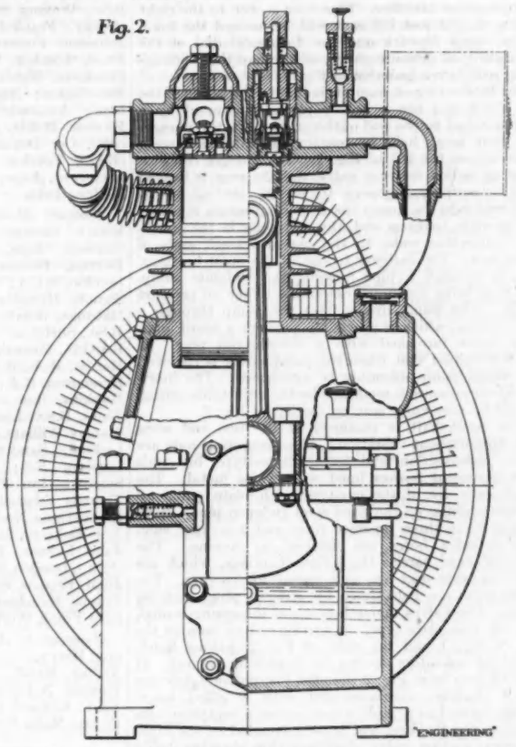


Fig. 2.



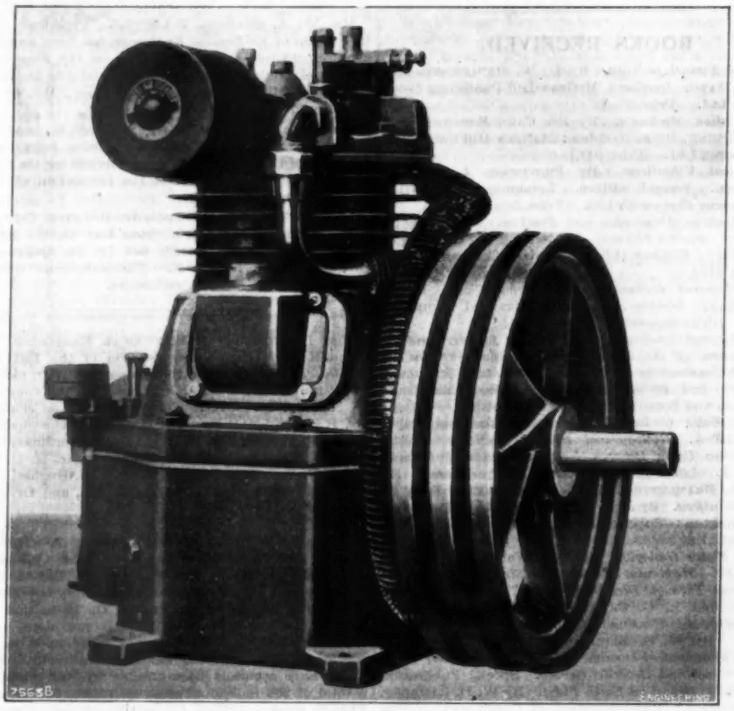


FIG. 3. COMPRESSOR ARRANGED FOR DRIVING BY VEE BELTS.

HIGH-PRESSURE TWO-STAGE AIR-COOLED AIR COMPRESSOR.

THE range of small air compressors manufactured by Messrs. Broom and Wade, Limited, High Wycombe, for charging the starting-air bottles of internal-combustion engines has recently been extended by the two-stage two-crank air-cooled machine illustrated in Figs. 1 to 3, on this page. For a considerable time the demand has been met satisfactorily by the firm's single-cylinder single-stage compressor, known as the "N type" compressor, which is suitable for pressures up to 350 lb. per square inch. Recent engine practice, however, necessitates high pressures and the machine now described, and known as the "T.N. 8 type" compressor, will deliver at from 150 lb. up to 450 lb. per square inch, the increase of pressure being obtained by the adoption of two-stage compression. The general construction will be clear from the sectional views, Figs. 1 and 2, while the external appearance of the machine is shown in Fig. 3. In this view the compressor is arranged as an independent unit driven by Vee belts on the flywheel periphery, but it is also supplied in a self-contained form, mounted on a common base plate with an air-cooled petrol engine which drives the compressor by means of a flat belt. As regards capacity, at the normal speed of 550 r.p.m. the delivery of free air per minute at a pressure of 450 lb. per square inch is approximately 5·85 cub. ft., the power consumption at the shaft being just under 2·6 brake horse-power. When delivering air at a pressure of 150 lb. per square inch and running at this speed, the capacity is about 6·25 cub. ft. of free air per minute and the power required is given as 1·86 brake horse-power. Obviously, if higher speeds are employed, a much larger capacity is obtainable, though higher speeds are only suitable for the lower pressures; thus, at a pressure of 150 lb. per square inch the delivery of free air is about 7·75 cub. ft. per minute when running at 700 r.p.m. and consuming 2·6 brake horse-power.

The low-pressure cylinder is 4 in. in diameter and the high-pressure cylinder is 1¼ in. in diameter, the stroke being 2 in. The cylinders are cast integrally with the crankcase and adjacent walls are separated so that the whole exterior is subject to the cooling air flow, deep fins being provided. The bedplate to which the crankcase is bolted is formed with a deep sump and rests on four feet. The joint between the crankcase and bedplate is on the centre line of the crankshaft. There is a plain gunmetal bearing, lined with white metal, in each end wall, and access to the

the cut, while the other position couples it to a high-speed countershaft for rapid traverse between the cuts. The switch is operated by a conical portion of the spindle housing. The base of the machine is of somewhat unusual construction. The top is formed of a heavily-ribbed casting, but the pedestals are of pressed sheet steel, about 0·138 in. thick. The corners of the feet, however, are cast and are welded on, as also are certain bosses and facings for connections. This product of the Hunter Engineering Company, and some other machines made by the same firm, are distributed in Great Britain by Messrs. Broadway Engineering Company, Limited, Carlisle-road, Hendon, London, N.W.9.

bushes is obtained by lifting the cylinder block bodily, after removal of the lubricating pump cover seen on the left of Fig. 1 and the oil seal on the right. The crankcase has a large access door on each side, as shown in Fig. 2, one of the doors having a combined oil filler and crankcase breather. This door is seen to the right of Fig. 2, and just below it will be noticed the knob of the sump dipstick and the horizontal dial of the lubricating-oil pressure gauge, all three of these fittings being readily recognisable in Fig. 3.

The lubricating-oil pump is bolted to the inside of the end cover and has a hollow plunger actuated by a cam attached to the end of the crankshaft, the plunger and cam being held in contact by a helical spring as shown on the left of Fig. 1. The plunger contains a spring-loaded delivery valve and the cam is formed with a peripheral groove to permit the oil to be delivered into the pump chamber from which it passes to the main bearings and, through holes in the cranks and connecting rods, to the big and small ends of these rods. The delivery to one of the main bearings, etc., is through a pipe crossing the bedplate sump, this pipe being continued externally to the oil pressure gauge. The pump draws from the sump through a filter screen, which is accessible through a small auxiliary cover furnished with a clearing-rod plug. It will be realised that when the pump cover is removed the whole pump assembly is withdrawn. The lubricating-oil pressure is regulated by the adjustable spring-loaded by-pass valve seen on the left of Fig. 2.

The crankshaft is balanced at the two end webs and runs without vibration. The connecting rods are of H cross-section and have marine-type big ends with gunmetal bushes lined with white metal. The small ends are of the eye-type with plain gunmetal bushes working on the fixed steel gudgeon pins. Both pistons have three pressure rings and a scraper ring. The cylinder bores are finished by honing. The cylinder head carries the valve chambers, which are kept separate and are well finned for cooling. The valve seats are held down by screwed plugs forming cages. The valves themselves are of the spring-loaded, low-lift, thin-plate type, the suction valves, seen on the left of Fig. 1 and the right of Fig. 2, having hand-actuated unloading devices for light-load starting. It will be seen from Fig. 2 that the low-pressure delivery valve chamber communicates with a gilled inter-cooler formed as a pipe, which makes a complete turn close to the flywheel and is then coupled to the high-pressure suction valve chamber, this chamber being fitted with a spring-loaded relief valve. The dotted outline near this valve indicates the position of a viscous type suction filter on the low-pressure suction inlet, this filter being prominent in Fig. 3. The relation of the intercooler to the pulley flywheel is perhaps best seen in Fig. 1, though this view does not show the form of the flywheel arms. Reference to Fig. 3, however, will make it clear that the arms form a fan, this construction ensuring a strong stream of air over the inter-cooler and cylinders. The compressor is very compact, its overall height being 22½ in., and the overall width, *i.e.*, the diameter of the pulley flywheel, being 14½ in. The overall length when a single pulley is fitted is about 18 in., though this is increased when a loose pulley with striking gear is required. The net weight is 176 lb.

ALUMINIUM ALLOYS FOR COMMERCIAL-VEHICLE CONSTRUCTION.—A commercial motor vehicle built largely of aluminium alloys recently collided, at a fairly high speed, with a concrete barricade. The body of the vehicle, a 6-ton composite meat van, is covered in aluminium-alloy sheet, while the underframe is constructed throughout of aluminium alloys. The design, which is of a simple robust type, utilises more or less standardised components and was evolved by the operators and body builders in collaboration with Messrs. Northern Aluminium Company, Limited, who supplied the materials. As a result of the accident, the body did not leave the chassis but merely moved forward 2 ft. and still remained resting on the underframe. The driver was only slightly injured. It is stated that just forward of the body, in the upper flange member of the main chassis frame, there was a slight collapse in the form of a buckle, this being indicative of the severity of the impact. Examination also revealed that the body had not been sufficiently rigidly attached to the bearers over their centre sections, where the longitudinal bracing contributes the greatest strength. At these points the bolts sheared and allowed the impact to be transferred to the unbraced ends of the cross bearers, bending them forward. It is pointed out, however, that the damage was such that when the repair of the vehicle was reviewed, it was found that the majority of underframe parts could be replaced after straightening. The outcome of this accident is stated to have confirmed a previous decision of the operator to concentrate on the use of aluminium alloys and to continue to re-equip his fleet with vehicles of this type when the war-time restriction on the use of aluminium is removed.

INSTITUTION ELECTIONS.

INSTITUTION OF ELECTRICAL ENGINEERS.

Associate Member to Member.—Leonard John Bamber, Timperley, Altrincham; Harold Gordon Campbell, B.Sc., Woking, Surrey; Arthur Edward Clarke, Manchester; Frank Jasper Cole, West Bromwich; William Johnston Forster, London, E.17; Thomas George Frost, London, W.C.2; Lt.-Col. Walter Cyril Huff, Stanmore, Middx.; Arthur John King, B.Sc. Tech., Manchester; Augustus Manighetti, Solihull, Birmingham; Alexander William Montgomery, B.Sc. Tech., Harrow, Middx.; Harold Hill Mullens, B.Sc., Eaglescliffe, Co. Durham; Arthur Muir Parkinson, B.Sc. (Eng.), London E.8; John Arthur Smale, B.Sc., Brentford, Essex; Pappu Subba Rao, B.A., Guindy, Madras, India.

Associate Member.—James Leslie Ashford, Sidcup, Kent; George Cecil Base, Windermere; Sidney Clarence Bunn, Worcester Park, Surrey; Simeon Buxton, Burton-on-Trent; Ernest George Cooper, London, S.E.3; Major Robert Harry Copeland, Royal Signals, Hounslow, Middx.; Mehrwanji Dalal, B.Sc., Matunga, Bombay, India; Alexander Stephen Gibson, B.Sc., Surbiton, Surrey; Lieut. Amir Chand Gossain, I.A.O.C., Menzai, N.W.F.P., India; Alexander Merrie Hardie, M.A., B.Sc., Aberdeen; Lt.-Col. James Lomas Henderson, B.A., Chislehurst, Kent; Herbert Desmond Hopkins, B.Sc., Stamford, Lincs.; Idris ab Gwilym Jones, B.Sc., Llangefni, Anglesey; Major (T./Lt.-Col.) Stanley William Joslin, B.A., Chislehurst, Kent; Cyril Lawton, Sanderstead, S. Croydon; George Lee, London, E.5; James McAlister, B.Sc., Crawley, Sussex; Ian Forbes Meiklejohn, London, S.W.1; Thomas Edward D. Menzies, B.Sc., London, S.E.9; Leslie Hans Norballe, B.Sc., Billericay, Essex; John J. O'Doherty, B.Sc., Blackrock, Co. Dublin; Dennis John Palmer, Birmingham; Hendrik Rissik, B.Sc. (Eng.), London, S.W.6; Maurice Scott, London, S.W.1; John Francis Smee, Manchester; George Frederick Travis, Manchester; William Ward, Bradford; Leonard Frank Worthy, London, E.C.4.

Associate to Associate Member.—Sydney Cyril Harling, Harrogate; William Norman Kilner, Altrincham; Arthur Marsh, Derby; Francis Albert Matthews, Tientsin, N. China; Ernest William Semmens, London, E.8; Edward Osmun Stewart, Morecambe, Lancs; Padma Malla Sundar, B.Sc., Biratnagar, Behar, India.

BOOKS RECEIVED.

Practical Tunnel Driving. By H. W. RICHARDSON and R. S. MAYO. London: McGraw-Hill Publishing Company, Ltd. [Price 21*s.*]

The Aviation Mechanic. By DR. CARL NORCROSS and J. D. QUINN, JUNR. London: McGraw-Hill Publishing Company, Ltd. [Price 21*s.*]

Mechanical Vibrations. By PROFESSOR J. P. DEN HARTOG. Second edition. London: McGraw-Hill Publishing Company, Ltd. [Price 35*s.*]

Steam-Turbine Principles and Practice. By TERRELL CROFT. Second edition. Revised by S. A. TUCKER. London: McGraw-Hill Publishing Company, Ltd. [Price 21*s.*]

Spectrochemical Analysis of Metals and Alloys. By F. TWYMAN. London: Charles Griffin and Company, Ltd. [Price 21*s.* net.]

Metal Aircraft Construction. A Review for Aeronautical Engineers of the Modern International Practice in Metal Construction of Aircraft. By MARCUS LANGLEY. Fourth and revised edition. London: Sir Isaac Pitman and Sons, Ltd. [Price 15*s.* net.]

United States Geological Survey. Professional Paper No. 196-A. *Geology and Biology of North Atlantic Deep-Sea Cores Between Newfoundland and Ireland.* Part I. *Lithology and Geologic Interpretations.* By M. N. BRAMLETTE and W. H. BRADLEY. Part II. *Foraminifera.* By J. A. CUSHMAN and L. G. HENBEST. Washington: Superintendent of Documents. [Price 30 cents.]

United States Geological Survey. Water-Supply Paper No. 847. *Maximum Discharges at Stream-Measurement Stations Through December* 31, 1937. By G. R. WILLIAMS and L. C. CRAWFORD. *With a Supplement Including Additions and Changes Through September* 30, 1938. By W. S. EISENLOHR, JUNR. Washington: Superintendent of Documents. [Price 30 cents.]

United Coast and Geodetic Survey. Special Publication No. 223. *Report on Earth Tides.* By W. D. LAMBERT. Washington: Superintendent of Documents. [Price 10 cents.]

Power System Interconnection. (Transmission Problems). By H. RISSIK. London: Sir Isaac Pitman and Sons, Limited. [Price 25*s.* net.]

United States National Bureau of Standards. Building Materials and Structures. Supplement to Report BMS 17. *Sound Insulation of Wall and Floor Constructions.* By V. L. CHRISLER. Washington: Superintendent of Documents. [Price 5 cents.]

PERSONAL.

MR. H. A. SHORT, M.C., M.Inst.T., assistant docks and marine manager, Southern Railway, Southampton, has been made acting docks and marine manager during the absence of MR. R. P. BIDDLE as Deputy Ports Director at the Ministry of Transport. Mr. Short has also succeeded Mr. Biddle as chairman of the Emergency Committee of the Port of Southampton.

MR. E. H. CLIFFORD was inducted as President of the Institution of Mining and Metallurgy at the fiftieth annual general meeting of the Institution, held in London on May 15. The retiring President was MR. THOMAS PRYOR.

MR. R. M. HANNAH has been appointed instructor in ore dressing, assaying, heat treatment and technical chemistry at the School of Mines and Industries, Ballarat, Victoria, Australia.

MR. R. W. AYERS has been appointed general manager of Messrs. Sciaky Electric Welding Machines, Limited, Farnham-road, Slough, Bucks. He has been responsible for the sales activities of the company for a number of years. Mr. Ayers is also attached to the advisory service on welding of the Ministry of Supply.

MR. JAMES MACFADZEAN, B.Sc., A.M.Inst.C.E., assistant engineer to the Trustees of the Clyde Navigation, 16, Robertson-street, Glasgow, C.2, has succeeded MR. A. C. GARDNER, M.Inst.C.E., M.I.Mech.E., F.R.S.E., as engineer to the Trust. Mr. Gardner has retired owing to ill-health.

MR. C. C. REID has been re-elected President of the Mining Institute of Scotland for the ensuing year.

DR. H. L. GUY, F.R.S., has been appointed chairman of the Engineering Research Committee at the National Physical Laboratory in succession to the late SIR NIGEL GRESLEY.

MESSRS. STEWARTS AND LLOYDS LIMITED, have removed the offices of their Publications Department from 145, Queen Victoria-street, London, E.C.4, to Winchester House, Old Broad-street, London, E.C.2.

MR. G. L. A. DOWNING, A.M.I.Mech.E., has been appointed Borough Engineer and Surveyor to the Borough of Hackney.

MESSRS. THE AEROGRAPH COMPANY, LIMITED, have found it necessary to transfer their London business from their City offices and showrooms, at 43, Holborn Viaduct, E.C.1, to their factory and general offices at Lower Sydenham, S.E.26. (Telephone: SYDenham 6060.)

MR. W. A. STANIER, M.I.Mech.E., President of the Institution of Mechanical Engineers, has been appointed a representative of the Institution on the Engineering Divisional Council of the British Standards Institution in place of MR. E. BRUCE BALL, Wh.Ex., M.I.Mech.E., Past-President of the Institution.

MR. ASA BINNS, Wh.Ex., M.I.Mech.E., and MR. DAVID E. ROBERTS, M.I.Mech.E., have been elected members of the Engineering Joint Council for the session 1941-42, as representatives of the Institution of Mechanical Engineers.

MESSRS. THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, inform us that, as from May 24, the address of their Manchester branch will be 15, Quay-street, Deansgate, Manchester, 3. The telephone number, Blackfriars 2691, remains unchanged.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The Committee of the Wireless Section of the Institution of Electrical Engineers have nominated certain members to fill the vacancies which will occur on the committee on September 30 next. These comprise, as chairman, Mr. H. Bishop, C.B.E., B.Sc. (Eng.); as vice-chairman, Mr. A. H. Mumford, B.Sc. (Eng.); and as ordinary members of the committee (five vacancies), Mr. H. G. Beer, Mr. F. P. Best, M.Sc., B. Eng., Mr. H. G. Hughes, M.Sc., Professor Willis Jackson, D.Sc., D.Phil., and Dr. H. A. Thomas.

SOUTH-WEST ESSEX TECHNICAL COLLEGE.—The Principal of the South-West Essex Technical College and School of Art, Dr. H. Lowery, M.Ed., F.Inst.P., states in the second annual report of the College, covering the academic year ending on August 31, 1940, that each department has responded to the maximum of its capacity to all the new demands made upon it, with considerable gain to the national endeavour. Enrolments have naturally been affected by war conditions; a total of 206 individual students registered during the 1939-40 session, against 473 in the previous year. For the first time, students were enrolled in the Department of Engineering for the final year of the Higher National Certificate in Mechanical and Electrical Engineering. Fifteen students were enrolled and it is pleasing to note that every one gained his Higher National Certificate. In addition, 29 Ordinary National Certificates were obtained, 13 in electrical engineering and 16 in mechanical engineering. Students in the chemistry and building departments also gained National Certificates.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—It was reported during the past week that owing to the improved transport position and in order to meet the increasing demand for Welsh coals it had been decided to reopen three pits in the anthracite area which had been idle for some time. The pits were the Maerdy, Gwaun-Cae-Gurwen and the Saron and Jubilee at Ammanford, all owned by Messrs. Amalgamated Anthracite Collieries, Limited. There was good business on the Welsh steam-coal market throughout the past week. Both home and overseas customers were showing a sustained interest. Inland industrial users were anxious to make heavy purchases of the high-volatile bituminous sorts, and there was, in addition, a good request for coals for stocking purposes as a precautionary measure for next winter. Most producers had already entered into sufficiently heavy commitments to provide them with an outlet for the bulk of their potential outputs for some time ahead and consequently the supplies available for early delivery were restricted. The activity in the home section provided a ready outlet for the supplies displaced from the export trade and the general tone was very firm. The current outputs of the best large qualities were being steadily lifted under existing orders and the tone was maintained, while offers of sized descriptions were only made with reserve. The best feature of the market was provided by the bituminous smalls, which were in brisk demand, and with order books well filled ahead commanded good prices. The dry steam smalls, however, failed to show any improvement and were again quiet and dull. Cokes were in good demand.

The Iron and Steel Trade.—Activities in the iron and steel trades of South Wales and Monmouthshire were well maintained during the past week. Most works were engaged almost to full capacity and there was a considerable amount of new business available.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Production is being speeded up in this area, and wasted time is to be reduced to a minimum. Employers and workmen are collaborating wholeheartedly in this effort. The demand for raw and semi-finished materials has been well maintained, and the users have complete confidence that the producers will distribute supplies equitably. There is a heavy demand for basic billets, and the requirements for acid steel and other materials are increasing. Good business continues to be done in scrap, and consumers have little difficulty in obtaining adequate supplies. The re-rollers of strip and small bars are working at full capacity. Specifications for structural steel are more numerous. Forges, foundries, press shops, rolling mills, billet mills, and sheet mills are all accounting for increased outputs. The recent revival in the demand for railway rolling stock is developing on satisfactory lines; British railways are good customers, but the overseas market shows little activity. Local works are benefiting from orders placed by British railways for wagons and carriage parts. Points and crossings of manganese steel are in strong demand, and local works have completed contracts for some complicated designs. The market in reconditioned machinery is extremely active. Steelworks and ironworks machinery and related equipment are in strong request. Boilermakers are busy; high-pressure vessels are required for various purposes. All types of special steels are in strong demand. Grinding and boring machinery finds a ready market; South Africa relies chiefly on this area for supplies of such equipment, and also for washing and refining plant used in the treatment of precious metals. Tool works are operating at full capacity, and the outputs have shown a steady increase during the past six months.

South Yorkshire Coal Trade.—The export market has undergone little change, though a healthy tone prevails on inland account. Industrial coal finds a ready market; locomotive coal is moving more freely, and smalls and slacks are steady. The house coal market is normal and the coke position is highly satisfactory.

THE INSTITUTE OF TRANSPORT.—The Council of the Institute of Transport has elected as President for the year commencing October 1, 1941, Mr. J. S. Nicholl, C.B.E., chief executive officer and director, Messrs. McNamara and Company, Limited. Other officers elected for the year 1941-42 included Sir Charles Bressey, C.B., C.B.E., and Messrs. H. M. Cleminson, Ashton Davies, C.V.O., O.B.E., G. Mills, E. J. Missenden, O.B.E., and R. Stuart Pilcher, as vice-presidents, and Sir Henry P. Maybury, G.B.E., K.C.M.G., C.B., as honorary treasurer. The Council also announced, with regret, the sudden death, on May 5, of Mr. E. Lee, traffic manager, Port of Bristol Authority, and honorary secretary of the Bristol and district section of the Institute since 1927.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Practically the whole of the heavy and increasing supply of iron and steel is absorbed by priority users, and buyers have considerable difficulty in obtaining the commodities needed for general commercial purposes. The aggregate tonnage output remains at nearly a record level and imports from the United States and the Dominions are steadily increasing. On the whole, the statistical position is satisfactory. Sources hitherto untapped are contributing substantially to certain essential requirements and have assisted greatly in relieving the congestion of orders at works on the North East Coast.

Cleveland Iron Trade.—There is still very little Cleveland pig obtainable and no prospect of an appreciable addition to the light intermittent production, but the gradual increase in the requirements of users of foundry iron is amply met by regular deliveries of brands manufactured elsewhere. Business passing through merchants' hands is on a slightly increased scale. Fixed prices of Cleveland pig remain at the equivalent of No. 1 description at 128*s.*, delivered within the Tees-side zone.

Basic Iron.—The nominal figure for basic iron remains at 120*s.* 6*d.* Makers are turning out sufficient tonnage for the needs of their own steelworks and continue to provide occasional small surplus parcels for emergency stocks, but have no iron to spare for the market.

Hematite.—The outlook in the hematite branch of the trade is regarded as definitely more favourable than has been the case for some time. Although the shortage of iron still necessitates strict rationing of customers and economy in use, the imports of American iron are expected to be on a much improved scale. Official quotations remain at the level of No. 1 grade of hematite at 138*s.* 6*d.*, delivered to North of England buyers.

Foreign Ore.—There is still difficulty in obtaining hematite ores, but other descriptions of foreign raw material are coming to hand in adequate quantities. All consumers, however, are making extensive use of local and other native ironstone in place of foreign ore.

Blast-Furnace Coke.—Holders of Durham blast-furnace coke have a large tonnage for disposal, but have extensive contract obligations and are not pressing sales; under such conditions new business matures slowly. The recognised market values are ruled by good medium qualities at 35*s.* 6*d.* f.o.r.

Manufactured Iron and Steel.—Semi-finished iron and steel stocks are substantial and as deliveries of bars, billets, blooms, etc., are maintained on a very satisfactory scale, the continued exceptional activity of the re-rolling plant is ensured. The output of most finished commodities is passing into use as soon as it becomes available, and the tonnage imported from overseas is rapidly taken up. The demand for shipbuilding material continues to increase and all descriptions of constructional steel, sheets, special alloy steels and railway requisites are in heavy demand. Soft-steel billets are quoted at 12*l.* 5*s.*; hard billets at 13*l.* 12*s.* 6*d.*; joists and sections at 15*l.* 8*s.*; heavy ship plates at 16*l.* 3*s.*; and heavy rails at 14*l.* 10*s.* 6*d.*

Scrap.—The demand for iron and steel scrap is still in excess of the exceptionally heavy supply, pressure being greatest for heavy grades.

THE GANTT MEDAL FOR INDUSTRIAL MANAGEMENT.—The Gantt Medal Board, on which are representatives of the American Society of Mechanical Engineers and the Institute of Management, has announced the 1940 Henry Laurence Gantt Memorial Gold Medal for "distinguished and liberal-minded leadership in the art, science, and philosophy of industrial management in both public and private affairs" to Mr. W. L. Batt, deputy director, Production Division, Office of Production Management, Washington. The Medal was presented to Mr. Batt by Mr. W. A. Hanley, President of the American Society of Mechanical Engineers, at Philadelphia, on April 22.

THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.—The forty-sixth ordinary general meeting of the Incorporated Municipal Electrical Association will be held at the Clifton Picture House, Clifton, York, on Thursday, June 12, at 11.0 a.m. The meeting will be preceded by an extraordinary general meeting at 10.30 a.m. for the purpose of amending the Articles of Association. It has been represented to the Council that inasmuch as the elections of certain local authorities normally take place early in April, the period for nominations by representatives of members should, if possible, not expire until after the elections have been held. In order to give more time for such nominations, it is proposed that the period should be extended, from five weeks after the date of circulation of the Council nomination list to six weeks. The offices of the Association are at Wigston Grange, Wigston, Leicester.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—To-night, 6 p.m., Storey's-gate, St. James's Park, Westminster, S.W.1. Informal Meeting. Discussion on "Railway Refrigeration Problems," to be opened by Mr. F. C. Johansen.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North Midland Students' Section:* Saturday, May 24, 2.30 p.m., The Hotel Metropole, King-street, Leeds. Annual General Meeting. Short informal address on "The Prospects for Electrical Engineers," by Mr. W. Dundas. *Institution:* Monday, May 26, 6.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Informal Meeting. Discussion on "Looking Forward," to be opened by the President, Mr. J. R. Beard.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Tuesday, May 27, 6.30 p.m., 12, Hobart-place, Westminster, S.W.1. General Meeting. (i) "The I.A.E. Automobile Research Committee," by Mr. W. A. Tookey. (ii) "Co-Operative Research," by Dr. Edmund Giffen.

ROYAL INSTITUTION.—Thursday, May 29, 5.15 p.m., 21, Albemarle-street, W.1. "The Re-Planning of London," by Mr. W. H. Ansell.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Active conditions are still general in the Scottish steel trade and all works continue in full production. Specifications from the shipyards are coming in steadily and boilermakers are also specifying freely, but light plates are not so active. Makers of black and galvanised sheets continue to be fully employed, and have enough work on hand to keep them running steadily for many months. The raw materials position is still satisfactory, but steel makers would appreciate a more steady flow of steel scrap. Prices are unchanged, and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade the recent improvement continues and most of the works have a satisfactory tonnage on order. The rivet, bolt and nut makers all very busy and their orders for the necessary iron are fairly considerable. There has been no change regarding the re-rolling of steel bars, and as old contracts are being completed not many new ones are being received to fill up the order books. Pending a rush of new business, which is expected in the near future, the re-rollers are at present able to accept orders for prompt delivery. Good stocks of semi-manufactured material are now held. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—No change of any kind can be recorded in connection with the Scottish pig-iron trade and all the furnaces are in full blast. The output is large, but it is quickly taken up, particularly so by the steelmakers, who are consuming a large tonnage of hematite and basic iron. Foundry grades of iron are moving more freely and some further improvement is anticipated. Stocks of iron ore are now quite satisfactory. The present market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

THE CONTROL OF MERCURY.—The Ministry of Supply has announced that the Control of Mercury (No. 5) Order has been amended by the Control of Mercury (No. 6) Order (S.R. & O. 1941, No. 586, price 1*d.*), which came into force on May 3. The maximum selling prices of mercury salts fixed by the No. 5 Order remain unchanged, but maximum selling prices are now fixed for quicksilver, both in bottles of 76 lb. and in smaller quantities. Hitherto, the metal has not been subject to price control. The maximum price for quantities of over one bottle, but of less than 11 bottles, is 48*l.* 15*s.* per bottle; for greater quantities the price is 48*l.* per bottle, ex-sellers' premises in both cases. There are higher prices for lots of under one bottle and for re-distilled grades. The Ministry of Supply is prepared to sell commercially-pure virgin mercury to approved buyers, and applications and further particulars may be obtained from the Raw Materials Department (Mercury Control), Ministry of Supply, Warwick.

THE GRAND COULEE DAM ON THE COLUMBIA RIVER, WASHINGTON, U.S.A.

(*For Description see page* 401).

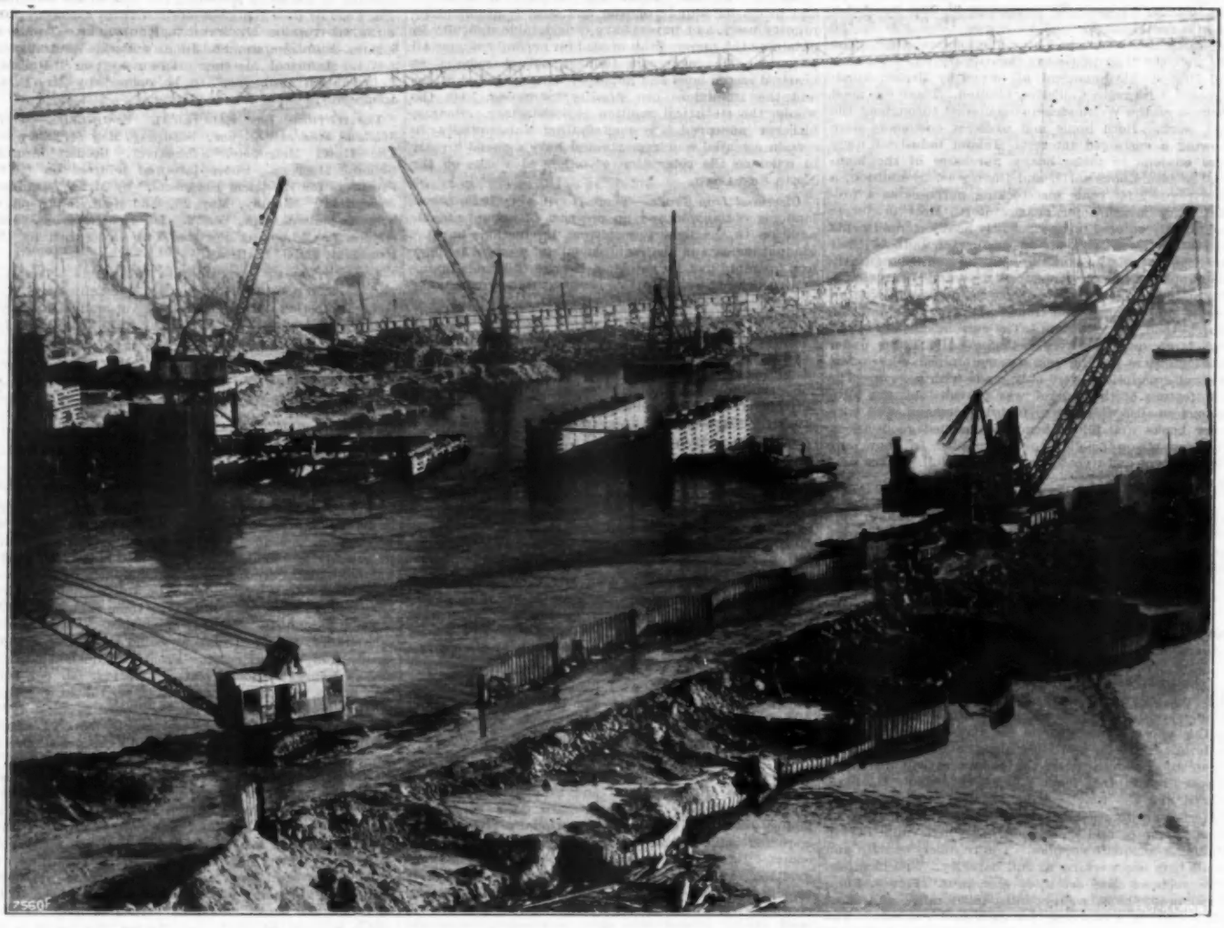


FIG. 13. EARLY STAGE IN CONSTRUCTION OF CROSS-RIVER COFFERDAM.

THE NON-FERROUS METAL COMMITTEES OF THE AMERICAN SOCIETY FOR TESTING MATERIALS.

DURING the "Committee Week" of the American Society for Testing Materials, which was held at Washington from March 3 to 7, well attended meetings took place of Committees B-5, on cast and wrought copper and copper alloys; B-7, on cast and wrought light metals and alloys; and B-6, on die-cast metals and alloys. Many problems were discussed and some interesting proposals submitted for final approval by the Society at its annual meeting in June. A number of recommendations affecting new and revised standards were placed before Committee B-5 for approval and submission to a committee letter ballot. These recommendations are briefly outlined below.

The sub-committee on copper-zinc sheet and strip submitted proposals for revisions in four tentative specifications for brass and leaded-brass sheet and strip. The sub-committee on miscellaneous copper-base sheet and strip alloys reported that specifications were being prepared for copper, sheet, strip and plate. This sub-committee also suggested revisions in the tentative specifications for beryllium-copper alloy bars, rods, sheet, strip and wire (No. B. 120-40 T.). The sub-committee on miscellaneous copper-base wire and rod alloys has been very active during the year and reported that four new tentative specifications had been drawn up. They concern, respectively, manganese-bronze rod; copper-nickel-zinc alloy rod and wire; phosphor-bronze wire; and phosphor-bronze rods, bars and shapes. This sub-committee also reported that it had in preparation new specifications for aluminium-bronze rods, bars and shapes for general engineering purposes, and specifications for commercial bronze rods and bars. Furthermore, revisions, prepared by this sub-committee were presented for incorporation in the standard specifications for free-cutting brass rod for use in screw machines (No. B. 16-29) and in the tentative specifications for copper rods, bars and shapes (No. B. 133-40 T.). The sub-committee on copper-base alloys for sand castings was also particularly active during the past year. It has completed seven new tentative specifications for sand castings, which will be companion standards to the specifications for copper-alloy ingots (No. B. 30-40 T.) presented to the Society last year.

At its meeting, Committee B-7, on cast and wrought light metals and alloys, gave careful consideration to the steps it might take to assist in overcoming a number of production problems. The Committee emphasised that one of the production bottle-necks in connection with aluminium sand castings has been the time involved in and the equipment necessary for the heat treatment of certain types of castings to produce high strength. A recent development in this field is a new aluminium alloy which has high strength properties in the as-cast condition, thus eliminating the need for heat treatment. Fortunately, it is stated, this new alloy can be easily cast and possesses good corrosion-resistance properties, as well as high strength. With regard to magnesium alloys in all forms, the Committee is proposing new high purity types which offer greater resistance to salt-water corrosion than the normal materials.

Committee B-6, on die-cast metals and alloys, which, owing to the extensive research work it has carried out, has had a great influence on the development and use of various pressure die castings and on the formulation of standard specifications for various alloys, considered methods of financing an extension of atmospheric exposure tests on zinc, aluminium, and magnesium alloy specimens. It was pointed out that the Committee's previous tests at various locations, extending over some ten years, should now be supplemented by information on new alloys, and a specia committee was appointed to appeal for contributions. Another committee was appointed to investigate, and report to Committee B-6 at its next meeting, whether there was sufficient interest in brass pressure die castings to warrant the formation of a new sub-committee. This subject, when discussed at the Committee B-6 meeting, elicited few comments other than that there would be considerable interest in brass die casting if die steels having a satisfactory life could be obtained. As the search for suitable die steels had hitherto been unsuccessful, it seemed unlikely that the commercial production of brass pressure die castings would increase materially in the near future.

It was further announced that the proposed changes in the composition of A.S.T.M. Zinc-Base Alloy XXV (No. B. 86-38 T.) involving the raising of the minimum magnesium limit from 0·02 per cent. to 0·03 per cent. and changing the maximum allowable tin limit from 0·002 per cent. to 0·005 per cent., would be submitted for approval to the Society in the 1941 Committee report. Papers dealing with modern methods of finishing aluminium, zinc and magnesium-alloy pressure die castings are expected to be ready for presentation at the 1941 annual meeting, and the committee hopes that these papers will be published as appendices to its annual report. Subject to approval by letter ballot, the sub-committee on magnesium-base die-casting alloys has prepared a specification for a new alloy to be known as No. 13X. This alloy is identical with alloy No. 13, in Standard Specification No. B-94, except that the iron and nickel contents are kept low (0·005 per cent. maximum) in order to obtain maximum resistance to salt-water corrosion. The mechanical properties of the new alloy are identical with those of alloy No. 13, the tensile strength specified ranging from 13 tons to 15 tons per square inch; the elongation on 2 in. from 2 per cent. to 5 per cent.; and the Charpy impact value from 1 ft.-lb. to 3 ft.-lb.

ENGINEERING.

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Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

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ENGINEERING

FRIDAY, MAY 23, 1941.

VOL. 151. No. 3932.

CARGO WINCHES.

ALTHOUGH, to the outside observer, progress in the design, manufacture and distribution of most commodities may appear to advance at a sensibly uniform pace over long periods of time, in fact it is usually achieved in a succession of fairly definite steps. Gradually the utmost advantage is extracted from available knowledge and materials, until the future seems to offer no better prospect of further advancement than some simplification in design or cheapening of production ; then some new factor is introduced, and at once the way is seen to effect a whole new range of improvements. Again and again this cycle will be found to repeat, each limiting factor in turn being overcome or circumvented and new limits set. The history of long-distance railway travel provides an excellent example of such progress. In the early days of railways, long-distance non-stop running was impracticable for many reasons, long after the systems of the various small companies were joined and the requisite lengths of continuous track were available. The advent of the corridor coach removed the first obstacle ; an innovation which probably had a greater influence on locomotive design than is commonly credited to it. Thereafter the limiting factor was the capacity of the locomotive rather than the endurance of the passenger, and subsequent developments, with one notable exception—the corridor tender introduced by the late Sir Nigel Gresley on the London and North Eastern Railway—have been in the direction of removing successive disabilities of the machine. The Ramsbottom trough overcame that of limited water capacity, and the main problem then became one of coal. Some alleviation in this respect was afforded by improvements in mechanical and thermodynamic efficiency, until the physical endurance of the fireman appeared to be setting a new limit. The corridor tender offered one way out of this difficulty, and mechanical methods of transferring coal from the back of the tender to the footplate have also been introduced. So far as this country is concerned, a limit is set to more extended non-stop running by the relative positions of the terminal points which can provide traffic to justify it, but if the inducement were present, it would seem that the next controlling factor to be surmounted would be the problem of maintaining a clean fire over more prolonged periods. Lubrication, of course, now presents no insuperable difficulties.

This is merely one illustrative example of a type of progress which might be paralleled in most branches of engineering construction, industrial manufacture, or the transport of goods. The evolution of the warship shows similar stages, and the development of aircraft is a still more recent instance. Under the stimulus of war, the successive changes are usually more rapid and the need to remove such bottle-necks in the path of progress is correspondingly more urgent. A suggestion of one direction which might repay closer examination in this respect was given in the concluding paragraph of the leading article in last week's issue of ENGINEERING, where reference was made to cargo-handling appliances on board ship. For a number of years these have been virtually standardised in type and arrangement, except in the case of a few vessels specially equipped to handle exceptional loads. Apart from these instances, practically the whole of the mercantile marine employs either steam or electric winches, and the steam winches, in general, have progressed very little in design during the past half-century or more.

The reasons for this apparent stagnation are mainly financial. As was pointed out by Mr. L. T. Morton in a paper on "Ships' Cargo-Handling Gear," delivered on February 14 before the North-East Coast Institution of Engineers and Shipbuilders, the manufacturers of winches have introduced many improvements, such as worm drive, grease-gun lubrication, and enclosed machine-cut gearing, designed to give better efficiency and decreased cost of maintenance ; but these naturally add to the capital cost, and many owners still prefer to buy in the cheapest market. Diesel-engined vessels commonly have electric winches, to avoid the need to keep an auxiliary boiler under steam for cargo-handling purposes, regarding the saving on the boiler and pipework as a sufficient offset against the greater cost of the electric winch as compared with the steam winch. Electric winches are also favoured for passenger ships because they are silent in operation. Despite the experience thus gained of electric winches, however, the simple steam winch appeared likely to survive for many years, to judge by the practice of shipowners up to the outbreak of war ; but the extent to which it was still being fitted in new ships was undoubtedly influenced by the fact that harbour crane equipment was becoming increasingly plentiful and efficient, and the demands upon a ship's gear correspondingly less. War conditions having necessitated so many departures from accustomed practice in the use of particular ports and berths, it is pertinent to inquire whether the cargo-handling equipment of the average ship is not liable to provide a new bottle-neck in the transit of goods.

Before the war, an average cargo vessel spent about 100 days a year in port. For some part of this time she would be in dock, undergoing survey or necessary overhaul, and for part she would be virtually laid up, or awaiting her turn to load or discharge ; but it is a safe assumption that 60 days, at least, would be occupied in working cargo. Mr. Morton appeared to favour a higher proportion, though without specifying any figure. Under war conditions, the period probably would be longer, owing to restrictions on night work, and to transport difficulties in removing the discharged cargo from the docks. Delays in waiting for convoys, and the loss of valuable time in steaming by devious routes and reducing speed to that of the slowest ship in the convoy, do not affect the time spent in actual cargo-working, but they do increase its relative importance in proportion to the effective point-to-point ton-mileage of which a given ship is capable. It follows that any improvement that can be effected in the speed of cargo handling is of correspondingly greater value.

We do not recall having seen, in the transactions of the various technical institutions, any critical analysis of the economics of cargo handling, though

some reference to its significance was made by Mr. A. T. Wall, some years ago, in discussing a paper at the Institution of Naval Architects. Mr. Wall pointed out that the increasing depth of hold in modern liners introduced a definite limitation of the rapidity of "turning round" at the end of each voyage, because of the height through which hoists of cargo had to be raised to clear the ship's side. This disability has been countered to some extent by increasing the light-hook speed of electric winches, but the ordinary type of steam winch does not lend itself to much improvement in this respect, without an appreciable increase in first cost. Merchant-ship building, in present circumstances, is subject to a higher degree of standardisation than has obtained at any previous period, since the two principal shipowning organisations now ordering new tonnage are the Governments of Great Britain and the United States. It would appear, therefore, that unusually favourable opportunities exist to-day for introducing a measure of standardisation into cargo-handling appliances, with a view to improving the efficiency of loading and discharging operations.

The principal objection to the electric winch, in many cases, has been that of first cost; but quantity production of a standard design should enable material economies to be effected if it is desired to extend their use in order to obtain the advantages of greater light-hook speeds. On the other hand, the electric winch undoubtedly requires a higher standard of workmanship, and calls for the use of more non-ferrous metal, the consumption of which it is desirable to restrict for military reasons. It is to be expected, therefore, that the steam winch will continue in favour, since it can be built in shops which could not readily undertake the production of the higher-grade electric product in any quantity. Also, it does not require such relatively elaborate control gear, which usually must be obtained from specialist sub-contractors. When it is recollected that the 60 standard cargo ships ordered in the United States on British account, from the subsidiaries of the Todd Shipbuilding Corporation, will require something of the order of a thousand winches, it will be seen that a certain degree of standardisation should offer appreciable advantages; and these ships represent only a fraction of the new tonnage required by the mercantile fleets of the Allies.

The obvious body to undertake such a policy is the British Standards Institution, acting in conjunction with the various shipping and manufacturing interests involved. The Institution has already carried out a certain amount of standardisation in connection with ships' deck equipment, such as bollards and fairleads, cargo-lifting blocks, boat davits, and anchor cables, so that there would be no objection in principle to extending the process to winches. It has been the policy, in all such cases, not to attempt to standardise design, lest this might lead to an undesirable restriction of technical development, but to concentrate on materials and on such overall dimensions as affect interchangeability; but even within these limitations, there should be ample scope for co-ordination. The suggestion may be made, however, that some relaxation of this general principle might be permissible in the case of a unit already so standardised by usage as is the simple form of steam cargo winch, in order to reduce the number of different components, facilitate replacement of worn parts, and to cut down to the minimum the quantity of spares that must be carried on board. This is not to propose the design of an entirely new type, compulsorily to supersede all those now being made; but the designs of the various makers, while many are outwardly similar, are not equal in operating efficiency, and a selection could be made of a limited number, of superior performance, the main dimensions of which might be capable of co-ordination as a basis of a war-time standard. Such modifications as would be necessary to secure, say, uniformity in size and position of holding-down bolts, sizes of pipe connections, and positions of controls, should call for no more than slight alterations to patterns, but would considerably promote quantity production and simplify erection and fitting; and concentration on faster types by reducing time in port, should amount in effect to a useful accretion of tonnage.

POWER FACTOR.

THERE are many conceptions the nature of which is well understood by the layman or the technician, although the exact and concise definition is a matter of some difficulty. Electrical engineering provides some examples of this difficulty of reconciling the abstract and the concrete; and among them the conception known as power factor may be cited. Every student knows that when an inductive load is supplied from an alternating-current system the cyclic variations which occur in the voltage and current are not coincident, though each, in turn, reaches a positive and negative maximum and also passes through a zero value many times in a second. He is also aware that, owing to this lack of coincidence, the power in watts is continuously changing; and its nominal value, as given by a wattmeter, is equal to the average value taken over a whole cycle of change. This nominal value is equal to the direct-current power which would give the equivalent heating effect in the circuit or, numerically, to the square root of the mean value of the square of the alternating current. If an inductive circuit is traversed by an alternating current and the root mean square amperes and volts, as they are commonly called, and the average watts are determined separately, it is found that the product of the first two values is not necessarily equal to the third. Though the latter value may be equal to the former, it will, in fact, generally be less. The ratio of the watts, or true power, to the volt-amperes, or apparent power, is called the power factor and if the current is sinusoidal, the power factor is equal to the cosine of the angle by which an alternating current lags behind or leads the voltage producing it.

The position may be made clearer by considering what happens when an alternating current flows in a reactive circuit. According to Faraday's law, a current flowing in a circuit induces an electromotive force which is additional to that causing the flow of the current and of a magnitude depending on the rate at which the current is changing and upon the inductance of the circuit. This "induced" voltage opposes the change in current which occurs in every alternating circuit, and must, in turn, be opposed if that continuously changing current is to be maintained. The direction of the pressures necessary for this purpose must be the same as that in which the increase in the current is taking place and will vary from a maximum to a minimum as the current increases from a minimum to a maximum. The effect of this in an inductive circuit, the resistance of which is negligible, is that the maximum values of line pressure occur one quarter of a cycle before those of the line current; in other words, the current lags behind the voltage by 90 deg. Moreover, as such a circuit has no resistance, the current can produce neither heat nor power, and is, therefore, said to be "wattless." As the power is zero, the power factor is obviously zero also. Similarly, in a circuit containing capacity but no inductance the current will lead the voltage by 90 deg. and once again will be "wattless." In a circuit containing both inductance and capacity the current will either lag or lead the voltage, depending on whether inductance or capacity preponderates. In a circuit consisting of a resistance-free inductance and an inductance-free resistance the current can be considered as consisting of two parts, one of which lags behind the voltage by 90 deg., while the other is in phase with it.

Thus there are in an inductive circuit two currents, one in phase with the supply pressure and one lagging behind this pressure by a quarter cycle. These combine to form a third, which lags behind the pressure by an amount depending on the values of the two components. In every inductive circuit the input is, therefore, equivalent to a power component and a "wattless" component. Power factor is the ratio of power consumption in watts to the product of R.M.S. volts and R.M.S. amperes.

Though the subject of power factor has always been of academic interest since the early days of electricity supply, it may be said that it only became of practical importance in the period between the two wars. During those years, alternating-current supply gradually assumed the preponderating position it now holds, and an ever-increasing use was made of the alternating-current motor for industrial purposes. The power factor of the supply to all alternating-current motors, excepting those of the synchronous type, is lagging. This is particularly the case with the largely used induction motor, which has the further property that its wattless demand increases more rapidly than the load. The result is that an increase in load, after a certain critical value has been reached, actually reduces the power factor. A further practical point is that the power factor of the supply to a motor for a given horse-power output depends very largely upon the size of the motor chosen for the duty. A slow-speed motor will require more wattless power per horse-power of output than one of higher speed and the full-load power factor of the slow-speed machine will, therefore, be lower than that of a high-speed machine of the same horse-power. In order to obtain the maximum power factor for a motor for a stipulated horse-power the rating of the motor should be chosen so that it corresponds as closely as possible to this duty and the speed of the machine should be fixed at the highest convenient value.

The subject is also of practical importance because the cost of giving an alternating-current supply depends upon the power factor at which it is distributed. From what has been said already, it will be clear that the current supplied to an alternating-current system with a power factor of 0·5 will be double the value it would have if the power factor were unity. Now the maximum load that can be supplied by the alternators, transformers, and other equipment depends on the current that can be carried continuously without overheating. This maximum load is proportional to the kilovolt-amperes, which are twice as great at a power factor of 0·5 as at unity power factor.

For this reason, a statement of the output of an alternator should not only give the number of kilowatts but also the power factor at which these can be supplied, or, alternatively, the output in kilovolt-amperes. In this connection, however, it is important to note, as Mr. H. M. Sayers has recently pointed out in *The Electrical Times*, that this does not mean that the energy can only be delivered at one particular power factor, but it defines the maximum current which the machine is designed to furnish without exceeding the prescribed temperature rise and indicates that the excitation provided is sufficient for the stated load at the minimum power factor. If the power factor is higher than the specified value, a load rather higher than that given by simple proportion can be carried since the lower excitation involves smaller field losses.

A considerable fraction of the standing costs of an undertaking supplying alternating current is inversely proportional to the power factor. This is the most important effect of low power factor on the overall cost of an alternating-current supply, though a secondary effect is that of increased losses. For instance, the loss in distribution and plant is four times as great with a power factor of 0·5 as with one of unity, and the kilovolt-ampere output per kilovolt-ampere delivered at the consumers' terminals will also be increased. These losses will slightly increase the standing costs per kilowatt and the running cost per kilowatt-hour delivered.

Tariffs have, therefore, been devised, the primary object of which is to increase the charge by an amount bearing some fairly equitable relation to the increased cost of supply due to low power factor. The effect of a power factor tariff on the consumer is to increase his bill if the power factor falls below a critical value and this increase is an inducement to him to install some method of correction. The power factors of consumers' installations are determined by the nature of the loads, not by the power factor of the supply system, and are to some extent under the consumers' control. The power factor of a distributing system is the resultant of all the consumers' power factors. It is advantageous to keep this high, as a low power factor increases the voltage drop and losses and the range of regulation needed to keep the voltage variation within prescribed limits.

NOTES.

THE BERKELEY CYCLOTRON.

LAST year the Rockefeller Foundation granted 1,150,000 dols. for the construction of a cyclotron of enormously greater size than any previously constructed. It is to be located at Berkeley, in California. The beam of the largest cyclotron in existence is capable of penetrating 5 ft. of air, but that of the Berkeley instrument will have a range of 140 ft. The beam voltage will be of the order of 100 million, and some 4,000 tons of copper and steel will be employed in the construction of the magnet. It is hoped with this new instrument to be able to produce particles capable of penetrating the nucleus of the atom. With cyclotrons at present in use, disintegration of the atom is confined to the outer particles, but the great advance which is now being made should enable the nucleus itself to be attacked. Much has been said and much speculation has turned on the possibilities which may lie in the utilisation of atomic energy. In many cases claims of early success in this direction have had little justification. From the laboratory experiments of Rutherford and others to the practical utilisation of atomic energy is a very long step, although as some abstruse physical experiments of the last 30 years or so have since proved to have far-reaching practical possibilities, it would not be wise to assume that the dream of atomic energy release may not have a legitimate basis. As practically all the energy of the atom is located in the nucleus, it is natural to suppose that if the new instrument permits it to be penetrated an important step forward may be possible, permitting not only the release, and conceivably the utilisation, of energy, but also throwing great additional light on the constitution of matter. As the cyclotron was invented and first developed by Professor Lawrence, of the University of California, it is fitting that the great instrument to which his investigations have led should be located in the same place.

REGISTRATION OF STORAGE PREMISES.

It is estimated that upwards of 14,000,000 sq. ft. of additional storage space is now required by Government departments for munitions, equipment, food, valuable raw materials, and other essential goods, and Sir Cecil Weir, whom the President of the Board of Trade recently appointed Controller General of Factory and Storage Premises, and Mr. P. A. Warter, the Controller of Storage, have together the task of finding this additional space. For this reason the Board of Trade has issued an Order (S.R. & O. 1941, No. 641) entitled the Storage Facilities (Information) Order, 1941. This stipulates that every person who owns premises situated in Great Britain, having a floor area of 3,000 sq. ft., or more, which premises have been used at any time since January 1, 1938, for the purpose of storing goods of any kind—whether or not they are now used for storage or other purposes—must give certain information concerning them. Owners of such premises should, therefore, apply as soon as possible to their local Chamber of Commerce or to any office of the Federation of British Industries or of the National Union of Manufacturers, or to the Registrar of Factory and Storage Premises, Board of Trade, Millbank, London, S.W.1, for a form on which this information may be given. The form, when completed, must be returned to the Registrar on or before June 2. Several classes of storage premises, however, are excepted from the provisions of the Order. These include garages; farm buildings used solely in connection with agricultural operations; premises used mainly in connection with a factory and situated within a mile of that factory; premises in respect of which a "return of factory premises" has already been made; and premises owned by local authorities and most public utility undertakings. It is pointed out, in connection with the Order, that the Government is dispersing stocks as widely as possible. In peace-time most commodities are stored in warehouses at the ports or other vulnerable areas, and the main effort of the Control of Factory and Storage Premises will be directed towards finding a large number of other premises to accommodate not only the goods displaced from more vulnerable areas, but also those now being produced in increasing volume by British factories and those of the Empire and the United States. The returns made under the Order, together with the returns now being collected relating to empty factory premises which cannot be used for production, will form the basis of the Control's register.

PRIVATE CHATTELS INSURANCE.

In view of various misunderstandings among the general public regarding the operation of the Government Scheme, under the War Damage Act, 1941, for the insurance against damage by enemy action of furniture and other private chattels, the Board of Trade have issued an explanatory notice. This points out that (*a*) it is not necessary to take out any policy of insurance to obtain the benefits of the Government's scheme of limited free compensation for war damage to furniture, clothing and other private chattels. Persons who do not want more protection than is provided by this scheme are not required to take any action unless and until their chattels have suffered damage. They should then apply to their Local Information Centre or the District Valuer for their district for a Form of Claim, which should be filled in and sent to the District Valuer. (*b*) Persons who want more cover than that automatically provided by the scheme of limited free compensation can secure the additional cover only by taking out a policy of insurance under the Private Chattels Insurance Scheme, which operates with effect from May 1, 1941. The period of grace allowed for taking out policies will expire on May 31, 1941, and no extension is contemplated. Persons who have not insured by that date will be entitled only to the benefits of the limited free compensation scheme for damage to their private chattels between May 1, 1941, and the actual date on which they take out a policy of insurance. Applications should be sent at once to a fire insurance company or Lloyd's broker or others carrying on insurance agencies. Insurance is voluntary and the fire insurance companies and Lloyd's will not circularise their clients on this subject. These arrangements apply to war damage to private chattels after April 30, 1941. Damage up to that date will be treated as if an insurance policy had been in force. No further action is required than the filling up of Form V.O.W. 1, obtainable from the local authority or the District Valuer.

UNITED STATES ARMS PRODUCTION.

A country not at war, but yet wishing to put its industry on a war footing, is in a difficult position. A state of war permits the introduction of regulations and controls which are not suitable, and would probably not be tolerated, in peace time, and, furthermore, a people at war is willing and emotionally capable of a long-continued effort which it could not sustain in time of peace. This state of affairs is illustrated by the conditions now ruling in the United States, where, with a Government and the enormous majority of the people entirely in favour of giving all possible aid to the democracies, output is from time to time being seriously interrupted by strikes. The trouble in the soft coal industry was got over only with difficulty, a shipbuilding strike still continues, and aeroplane engine construction has been prevented from serious interruption only by the granting of very substantial wage increases. As public opinion in the country swings more and more strongly in favour of the British cause, these troubles may be expected to decrease. Fortunately, even under the handicap of a nominal state of peace, the war output is showing remarkable increases; a testimony not only to the industrial capabilities of the country, but also to the efforts being made by the Government and the leaders of industry. In twelve months, military aeroplane production has risen from some 400 a month to 1,400, and is following a very rapidly rising curve. The output of this particular munition has naturally been helped by the previous existence of a large commercial-aeroplane industry. Even in matters which have no peace counterpart, such as tanks, very great progress, however, has been made. The great motor industry has naturally helped. Steel, the basis of most war industry, is now being produced at an annual rate of 80,000,000 tons, a figure which neither Germany, nor any other country, can approach.

CONCENTRATION OF PRODUCTION AND LIABILITY FOR TAXATION.

In answer to a question in the House of Commons on the taxation position of firms affected by the scheme for concentration of production, Captain Waterhouse, Parliamentary Secretary to the Board of Trade, stated that the Chancellor of the Exchequer had agreed to include in the Finance Bill provisions relating to the liability to taxation of concerns which are certified by the Board of Trade as being parties to approved arrangements for the concentration of production. The provisions will be to the following effect:—(1) For the purpose of computing income tax and excess profits tax, the cessation of its production by a concern when a factory is closed, or the undertaking by a nucleus concern of new activities, in consequence of concentration arrangements approved by the Board of Trade, will not be treated as effecting a discontinuance of the business of the one or the setting up of a new business by the other. (2) Any sum (except a sum of a capital nature or a sum payable under deduction of tax), payable as a result of an approved concentration arrangement to a closed concern by a nucleus concern, shall be allowed as a deduction in computing the profits of the latter and shall be treated as a trading receipt in computing the profits of the former. (3) If, in exceptional circumstances, an industry or a part of an industry sets up a central fund approved by the Board of Trade into which nucleus concerns pay levies and from which compensation is paid to closed concerns then the amounts paid in by the nucleus concerns (not being payments to be used for capital purposes) will be allowed as deductions in computing their tax liability, provided that there is no residue in the fund, and amounts drawn out by closed concerns will be treated as trading receipts. (4) In computing liability to excess profits tax the amount of capital represented by machinery and plant which, under a concentration scheme approved by the Board, a closed concern has temporarily ceased to use, will be regarded as still employed in the business. (5) The deduction allowable for income tax purposes for the wear and tear of machinery and plant will continue to be allowed to a concern which has closed as a result of an approved concentration arrangement, but still retains the machinery, and this deduction will be computed as if the machinery and plant were in normal use.

NAVAL EXPENDITURE IN 1939.

While it was not to be expected that much information would be disclosed about expenditure on the Navy until the end of the war, the report of the Comptroller and Auditor General, which accompanies the Appropriation Account for Navy Services for the year ended March 31, 1940, is not devoid of general interest. Naturally, as the Account covers seven months of active warfare, there is a considerable deficit, chargeable against the Vote of Credit passed by Parliament for general war services; actually, it is rather more than 30,000,000*l.*, less sundry extra receipts. Changes are noted in the contract procedure for warship construction, orders now being placed with selected shipbuilders who are known to have facilities available, on the understanding that a fair price will be fixed later. It is understood, adds the Comptroller, that the Admiralty propose to ascertain, as a guide, the actual building costs of a number of ships, completed at fixed prices since the beginning of the war. Particulars are given of the somewhat curious price basis employed when, under the supplementary programme for 1939, the Admiralty bought a number of trawlers at a cost of some 2,200,000*l.*; prices were calculated on a standard replacement figure for a deep-sea trawler 175 ft. in length, and were varied in proportion to the actual lengths of the vessels, with adjustments in respect of age and sundry technical differences. It is claimed that the result was favourable to the Admiralty. The report also includes notes on the Salvage Department set up by the Admiralty, the basis of merchant-ship building contracts, and the cost of hutted camps for training Special Reserve men.

THE TIDE-GENERATING FORCES.

By DR. A. T. DOODSON, F.R.S.

IN ENGINEERING of February 21, 1941, page 154, a letter appeared, over the signature "W. J. T.," asking for some interpretation of the forces which maintain the tidal "humps" of water over the surface of the earth. The present writer replied to this letter in another, published in the issue of March 7, page 195, but this was necessarily brief. The following summary of the main principles of tidal action, it is hoped, may dispel more effectively the misconception which inspired the original inquiry, and which is still very commonly held.

The two main principles to be borne in mind are as follows:—(*a*) Only the variations in attractive forces of the tide-generating bodies need to be considered, for, if all parts of the earth were to experience equal forces (equal in intensity and the same in direction), there would not be any movement of one particle relatively to another. The tide is a movement relative to the earth, and relative movements depend upon relative (or differential) forces. (*b*) Only the tractive force along the earth's surface can operate in tidal movements. This is readily seen by considering the three forces on a particle at the earth's surface. Let g denote the coefficient of gravitational force due to the earth, let X denote the horizontal component of differential force due to the attraction of the moon, say, on a particle of unit mass, and let Y denote the vertical component of this same differential force. We see at once that these forces, in effect, combine into two, X horizontally and $g + Y$ vertically. Any fluid, given sufficient time, will tend to set itself at right angles to the resultant force, and thus the equilibrium surface, if it could be attained, would make an angle $\tan^{-1}\frac{X}{(g+Y)}$ with the horizontal. But it is readily shown that both X and Y are very small compared with g, being, in fact, of the order of one ten-millionth part of g. The effect of Y, therefore, on the gradient of the fluid surface is negligible, for it would only affect the gradient by one ten-millionth part. If these two principles are firmly grasped, there will be no difficulty in computing the required tractive forces; and, in fact, these can be computed with very great exactness, for they depend only upon the gravitational properties of the solar system, and not upon the laws of hydraulics.

There are many ways of computing the tractive force, but the following is as simple and direct as any. In Fig. 1, herewith, let C be the centre of the earth, a the radius of the earth (which can be taken for all our purposes as spherical), P a point on the earth's surface, R the position of the moon, r the distance of the moon (C R), and let A, B denote the angles P C R, P R C, respectively. If g is the attractive force exerted by the earth on a particle of unit mass at P, then the attractive force of the moon on this same particle will be less in the ratio of the masses of the moon (M) and the earth (E), and less again in the ratio of the squares of the distances from P to the centres of the earth and moon, by the well-known law of gravitational attraction. That is, the attractive force of the moon on the particle of unit mass at P is given by $\frac{K}{PR^2}$, where

$$K = g\frac{M}{E}a^3.$$

The attractive force upon a particle of unit mass at the earth's centre is similarly given by $\frac{K}{CR^2}$. The former is directed along P R, and the latter along C R.

Now we have to decide as to the definition of the relative or differential force. Clearly, we ought to compare all forces everywhere with those at the centre of the earth, and the differential force will be the difference between the attractive force at P and that at C, taken vectorially, so that, if we transfer the force at C to P and take components of the two forces, we can then take the difference between the components. As we are only interested in the components along the surface, we resolve the forces along the surface and take the difference, which is the tractive force required. This is obviously given by

$$X = \frac{K}{PR^2}\sin(A+B) - \frac{K}{CR^2}\sin A;$$

and, since C R, on the average, is about 60 times greater than the radius of the earth, we can take $\frac{a}{r}$ as small, cos B = 1, and

$$P R \sin B = a \sin A.$$

$$r = C R = a\cos A + P R\cos B = a\cos A + P R$$

and thence

$$\frac{1}{PR^2} = \frac{1}{r^2}\left(1 + \frac{2a}{r}\cos A\right),$$

approximately.

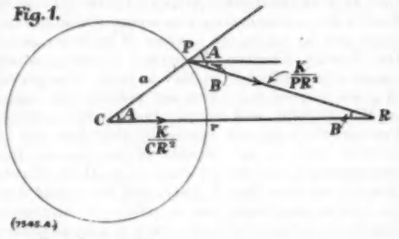
Following on this equation, we have

$$X = \frac{K}{r^2}\left\{(\sin A\cos B + \cos A\sin B)\left(1+\frac{2a}{r}\cos A\right) - \sin A\right\}$$

$$= \frac{K}{r^2}\left\{\left(\sin A + \frac{a}{PR}\sin A\cos A\right)\left(1+\frac{2a}{r}\cos A\right) - \sin A\right\}.$$

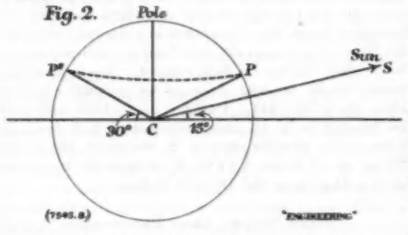
If we are only retaining the lowest order of small

Fig. 1.



(7545.A)

Fig. 2.



(7545.B) "ENGINEERING"

quantities, we can write in this expression, P R = r, whence

$$X = \frac{K}{r^2}\sin A\left\{\left(1+\frac{a}{r}\cos A\right)\left(1+\frac{2a}{r}\cos A\right) - 1\right\}$$

$$= \frac{K}{r^2}\sin A\left(\frac{3a}{r}\cos A + \ldots\right)$$

$$= \frac{3}{2}\frac{K}{r^3}a\sin 2A$$

$$= \frac{3}{2}g\frac{M}{E}\left(\frac{a}{r}\right)^3\sin 2A.$$

A similar formula can be written down for the tractive force due to the sun.

Some important conclusions can be easily drawn from the above formula. The value of $\frac{E}{M}$ is about 81·5, and the average value of $\frac{r}{a}$ is about 60·3; so that the average value of the coefficient of sin 2A is $8{\cdot}4\times10^{-8}\,g$. It can readily be shown that the vertical force is of the same order of magnitude as the horizontal component of differential force, so justifying the statement made above as to its neglect in relation to g.

Further, the value of X is zero when A is a multiple of 90 deg. The tractive force is thus zero immediately under the moon and away from it, and it is zero on the great circle at right angles to the line of centres of earth and moon. This may puzzle the unwary, who attempt to look for forces which are greatest under the moon, so that the water is pulled up under it. We shall have no difficulty if we remember that, if the equilibrium condition could be attained, the slope of the water surface would be proportional to X, and the maxima and minima of the surface would occur with X zero. Physically, of course, we see that under the influence of the tractive force the water would move towards the line of centres, and, given sufficient time, would form the two humps of the equilibrium surface under the moon, on opposite sides of the earth. The shape of this equilibrium surface can be obtained from X by integration, with the proviso that the total volume of water remains unchanged; but we shall not proceed to this exercise, for reasons now to be stated.

The inertia of the water is so great that the equilibrium condition is not attained. The equilibrium tide bears no relation whatever to tides in actual seas and oceans. The shape of the continents and the depth of the oceans profoundly affect the tide, and the further development of tidal theory becomes exceedingly complicated. Until recent years, only a few geometrically simple seas or oceans had been investigated, and the difficulties in discussing the tides in an ocean bounded by meridians have been so great that many years of labour have been expended upon them, with some success. At the present time, there is no immediate prospect of being able to say what the tides should theoretically be at all points of the coasts of the oceans as we know them. The problem is too vast.

What, then, is the use of the tidal theory if we cannot readily deduce the tidal elevations from it? The successful application of the theory depends upon Laplace's Principle, which asserts that "The state of a system of bodies in which the initial conditions of the motion have disappeared through the resistance which this motion experiences is periodic, like the forces which animate it." In other words, the tidal oscillations must be co-periodic with the tractive forces, so that every variation in the forces must lead to a variation of the same period in the tide, though the amplitudes and phase relations may not be predictable from theory alone. Since the forces are known with very great accuracy, it follows that, as we know what to look for in the tide, the rest is a matter of skill and labour in manipulating the actual observations.

The development of the tractive force X in terms of lunar and solar distances and positions is rather too technical for this article, but we can readily discuss in a simple way the variation of the tractive force under certain conditions. For simplicity of exposition, consider the case when the sun is 15 deg. N. of the equator, and the place P is in latitude 30 deg. N. In Fig. 2, herewith, we show two positions of this place, P′ and P″, for mid-day and midnight, respectively. The angle A then takes the values P′ C S = 30 deg. − 15 deg. = 15 deg., and P″ C S = 150 deg. − 15 deg. = 135 deg. Similarly, we find that, if the sun is on the equator, these two angles become 30 deg. and 150 deg.; and in this case sin 2A is numerically the same morning and afternoon, so that the forces tending to raise the tide at the equator and also at P are exactly the same after 12 hours. In other words, the tide will be the same in elevation, morning and afternoon.

Such, however, is not the case when the sun is off the equator, and, in the case of Fig. 2, while the forces reach their maxima at mid-day and midnight, the numerical values of the maxima are very unequal. There is thus a diurnal inequality in the tractive force, and we deduce the result that the force can be made up of a diurnal part and a semi-diurnal part. Laplace's Principle indicates that in the resulting tide we shall expect to find a diurnal part and a semi-diurnal part. Further, we see that the diurnal inequality vanishes when the sun is on the equator. Similar conclusions follow also for the lunar tide.

Particular attention has been paid to this matter of the diurnal tide because it is a mystery to many. The tidal oscillations in British waters have a misleading and spurious simplicity. It is natural for us to expect two tides of about the same range in the day, but in other parts of the world the heights of high water, morning and afternoon, vary very considerably, so that there will be a daily sequence of tides much higher than the intermediate sequence. When the moon is on the equator, once a month, this inequality is a minimum and there will be a change over in the sequences, as is indicated above.

If we examine the tide tables, we shall readily see that there is a diurnal inequality in these waters. Thus, for instance, from May 1 to May 8, 1941, the afternoon tide at London Bridge is less than the morning tide, though both sequences are altering in height from springs to neaps. Again, we see that the forces vary inversely as the cube of the distances of the tide-generating bodies, and we expect, and find, a similar response in the tidal ranges; though the relationship is not exactly that given by the formula for the forces.

Modern tide predictions are made by the use of machines. It was on account of the difficulties of predicting tides with large diurnal inequalities that Lord Kelvin was led to design the harmonic method and the predicting machines. The forces are resolved into harmonic components, the periods of which are thus ascertained, and the tidal observations are examined for oscillations of the same periods, according to Laplace's Principle. The relations between the forces and the tides are then expressed in the form of harmonic constants.

One other major tidal problem needs to be mentioned. Though the forces may yield harmonic variations, the tide exhibits higher harmonics which are not in the forces. These are due to the distortional effects of relatively shallow water upon a harmonic oscillation. This problem is purely a hydraulic one. Laplace's Principle is not vitiated, but it needs an amendment to indicate the possibility of higher periods being found. In practice, we find that the semidiurnal tide is accompanied by quarter-diurnal and sixth-diurnal tides, which are generated terrestrially from the main semi-diurnal oscillation indicated by the tide-generating forces. This is a consequence of the well-known fact that a wave cannot be propagated unchanged in shape in shallow water. This problem can be considered as of vital importance to accurate prediction of tides in estuaries, where the shallow-water effects are mainly generated.

OBITUARY.

SIR DAVID OWEN.

IT is with regret that we record the death of Sir David John Owen, which took place at Chicago, on May 17, while on his return home from Hong Kong, where he had been to advise the Government of the Colony on the administration of the port. Sir David, who was general manager of the Port of London Authority for 16 years, was the son of the Rev. R. Ceinwenydd Owen and was born at Liverpool on March 8, 1874. After receiving his education at Liverpool Institute, he entered the service of the Mersey Docks and Harbour Board and continued in their employ for 13 years. In 1904, he was appointed manager and secretary to Messrs. Paul Brothers, flour millers, of Liverpool and Birkenhead, but returned to port work in 1908, in which year he was made assistant manager of the Goole Docks. He became manager in 1915, but relinquished this position some months later to take up the appointment of general manager and secretary to the Belfast Harbour Commissioners. After occupying this position for seven years, he was appointed general manager to the Port of London Authority in 1922, and continued in this capacity until his retirement in 1938. While he occupied this position, some important extensions and improvement schemes were carried out in the Port of London, and accounts of these have appeared in our columns from time to time. In this connection, Sir David published several works, prominent among which were *The Port of London Yesterday and To-day*, issued in 1927; and *The Origin and Development of the Ports of the United Kingdom*, issued in 1939. He became a member of the Institute of Transport in 1920, served as President from 1932-33, and was a recipient of the Institute's Dock and Harbour Gold Medal. In 1937, he was appointed a member of the Holidays-with-Pay Committee, and, in 1939, was made chairman of the Merchant Shipping Reserve Advisory Committee of the Board of Trade. Sir David was also a past President of the National Confederation of Employers' Organisations. He received his knighthood in 1931.

THE DETERMINATION OF OXYGEN IN IRON AND STEEL

ONE of the contributions considered at the annual meeting of the Iron and Steel Institute, held in London on May 1, was the "Third Report of the Oxygen Sub-Committee," this being a progress report of one of the sub-committees of the Committee on the Heterogeneity of Steel Ingots. The report is divided into 11 sections, the first of which is introductory in character. The remaining sections, many of which are again subdivided into two or three parts, comprise contributions, by members of the sub-committee and their collaborators, constituting detailed studies of existing methods for the determination of oxygen and other gases in steel and iron. The aim of the authors is to describe as concisely as possible the essential items on which an advance has been made since the publication of the second report in 1939, and to state the possibilities and limitations of the respective methods as they are practised to-day. The second section of the report deals with vacuum fusion and vacuum heating methods. In Part A of this section, Mr. H. A. Sloman emphasises the accuracy of determinations of total oxygen made by the vacuum fusion method, but draws attention to the importance of recognising the presence of surface oxygen, it having been shown that this may account for as much as 0·004 per cent. to 0·006 per cent. of oxygen in pure iron. Like that of oxygen, the present position with regard to the determination of nitrogen is considered by Mr. Sloman to be completely satisfactory, but that of hydrogen, on the other hand, is open to some doubt. An important point made by the author is his suggestion that the cold solubility of oxygen in high-purity iron lies between 0·006 per cent. and 0·003 per cent.

Part B of Section II, by Dr. T. Swinden (the Chairman of the Sub-Committee) and by Messrs. W. W. Stevenson and G. E. Speight, deals with the fractional vacuum fusion method for the separation of oxides and gases in steel. Typical results obtained by this method, on several types of steel, are given and are compared with results secured by the alcoholic iodine and the chlorine methods. The fractional vacuum fusion method has been found particularly successful in the examination of unkilled steels of the rimming type, where the oxygen is believed to be present as basic oxides not combined with any substantial amount of silica. With the present technique of the residue methods, the values of FeO and MnO in materials of this type are considered to be of doubtful value, being usually low. Moreover, if oxygen exists in solution in the steel, it is thought to be possible that the residue method may fail to separate oxygen existing in this form. Part C of Section II consists of a brief note by Dr. W. C. Newell, which constitutes an addendum to his paper on "The Estimation of Hydrogen in Steel and Other Metals," presented to the Institute last year.* He states that the single-stage mercury-vapour pump described has now been replaced by a similar two-stage pump. While the pumping rate is thereby improved and the degree of vacuum attained is presumably higher, no difference has been observed in the performance of the apparatus, which has continued to be used in a highly satisfactory manner for fundamental research work on the hydrogen-iron system.

As an alternative method to vacuum fusion for the determination of total oxygen alone, attention is directed to the aluminium reduction method introduced by Messrs. N. Gray and M. C. Sanders. In Section III, Part A, of the report, these authors detail the improvements introduced in the method since it was originally described. Essentially, the method consists in melting the steel sample in the presence of excess aluminium at about 1,150 deg. C.; the oxides are converted into alumina and the oxygen is estimated chemically as alumina. The chief improvement made in the method is that the atmosphere of hydrogen originally employed is dispensed with and the determination carried out in a tube from which the atmosphere has been evacuated to a pressure of 8 mm. of mercury by means of a Pulsometer pump. Results are given indicating excellent agreement with the vacuum fusion method when applied to carbon steels, and check tests, on compounds containing known weights of added oxides, show excellent oxygen recovery figures. This method has been in regular use for some time in the Central Research Department of Messrs. The United Steel Companies, Limited, and in Section III, Part B, Messrs. W. W. Stevenson and G. E. Speight contribute a description of their equipment and their experience. Comparison is made with results obtained by the vacuum fusion method and close agreement recorded on many types of ferrous materials. Further work on the aluminium reduction method is dealt with in Section III, Part C, in which Mr. E. Taylor-Austin describes a modified method applied to the determination of total oxygen in pig iron. The high silicon content in certain irons necessitates a modification of the original procedure, and evidence is submitted that the method can be applied satisfactorily to pig iron generally, provided that a suitable sample can be obtained.

Sections IV, V, VI and also VIII deal with the residue methods, in which the non-metallic inclusions are separated chemically from the iron and are subjected to chemical analysis, leading in turn to a calculated result for the oxygen content. Definite progress has been made in elucidating some of the earlier difficulties and discrepancies. In Section IV, Part A, Messrs. E. W. Colbeck, S. W. Craven and W. Murray describe the latest type of equipment and procedure employed for the chlorine method, as well as the improved technique adopted for the analysis of the residue. In Part B of this section, the same authors show the satisfactory application of the method to a wide variety of steels. Good agreement, in the total-oxygen figures, was obtained between the chlorine method and the vacuum fusion method on fully-killed plain carbon steels. In the case of rimming steel, lower results are obtained by the chlorine method, and it is suggested that the inclusions present in these steels may be susceptible to attack by chlorine at 350 deg. C., perhaps because they consist largely of FeO and MnO, present as such, and not linked with appreciable amounts of silica and alumina as in killed steels. In their earlier work, the authors showed that the chlorine method was very promising for certain alloy steels which contained elements known to interfere seriously with the iodine method, and an account is given of the further work which is being pursued in the application of the method to alloy steels.

Section V deals with the alcoholic-iodine method, and in Part A, Mr. T. E. Rooney shows that the method, as now practised, can be used for the accurate determination of the oxide-containing inclusions in low and medium straight-carbon steels not containing appreciable amounts of elements which form stable carbides or insoluble iodides. Such materials, it is pointed out, represent a large proportion of the total tonnage of manufactured steel. Incidentally, the author mentions the successful use of alcoholic-iodine solutions for stripping oxide films on iron. In Section V, Part B, Messrs. W. W. Stevenson and G. E. Speight describe a simplification of the alcoholic-iodine method, which, nevertheless, fulfils all the essentials and appears to produce results of sufficient accuracy for all practical purposes, subject, of course, to the limitations of the method previously referred to. Briefly, the simplified method consists in placing 10 grammes of the sample, in the form of pieces, together with the alcohol-iodine solvent, in a flask surmounted by an 8-in. Liebig condenser. An atmosphere of purified nitrogen is maintained in the flask, which is boiled gently. Solution is usually complete in from 5 hours to 6 hours, and, after allowing the reaction flask to cool, while still maintaining the flow of nitrogen, the solution is filtered through a tightly-packed paper-pulp filter previously washed with alcohol. The residue is washed rapidly with purified methyl alcohol, dried, ignited and weighed in the customary manner.

Recent developments in the determination of oxide inclusions in pig and cast iron by the aqueous iodine method are described in Section VI. In Part A, Mr. E. Taylor-Austin gives an account of the operation of a new and modified method. He states that the solution of manganous oxide, as such, during the decomposition of samples by the aqueous iodine-potassium iodide solution, cannot be prevented, and hence results for this oxide cannot be obtained at present. Iron carbide, iron phosphide, manganese sulphide and titanium carbide cause no interference in the new procedure. The present method has been successfully applied to a series of 45 different types of pig iron without experiencing new complications, and it is therefore believed that the process may be employed for the determination of oxide inclusions in all types of pig iron, excluding alloy irons, and that the results for SiO_2, FeO, MnO (existing as manganese silicate) and Al_2O_3 are reliable. In a general review of the present position of the determination of oxide inclusions in pig and cast iron, given in Part B of Section VI, Mr. J. G. Pearce states that the satisfactory accord between the results obtained on pig and cast irons by the aqueous iodine and aluminium reduction methods appears to indicate that the two methods may now be taken to be in a reasonably final form.

The hydrogen reduction method—one of the earliest ever proposed for determining oxygen in steel—has been the subject of intermittent attention for many years. Interest has been renewed in the possibility of accurately determining the more readily reducible oxides, such as iron oxide and manganese oxide, and, in Section VII, Mr. W. W. Stevenson briefly states the results of a considerable amount of work on the subject. This, unfortunately, up till the present, has not led to a satisfactory adaptation of the method, but the work is proceeding.

The technique of the analysis of residues, obviously an important subject, was dealt with at considerable

* See ENGINEERING, vol. 149, page 479 (1940).

length jointly by members of the Chemists' Panel in the last report of the sub-committee. In Section VIII of the present report, Mr. G. E. Speight, in an account of the analysis of non-metallic residues extracted by the alcoholic-iodine method, suggests some further improvement in the direction of the almost complete adoption of colorimetric methods. Section IX is headed "Reports on Materials Examined," and, in Part A, Dr. T. Swinden and Mr. W. W. Stevenson describe work on a billet of basic Bessemer rimming steel examined for oxygen content by the chlorine, alcoholic iodine and vacuum fusion (both total and fractional) methods. These results confirm the view that the residue methods tend to give low results, which, it is suggested, are due to the attack of the halogen reagent on uncombined iron and manganese oxides. It would appear that the fractional extraction method, as previously mentioned, is well suited to the fractional determination of oxygen in this type of steel. In Part B of Section IX, Dr. W. R. Maddocks presents a short note on the influence of carbon on the alcoholic iodine method for the determination of oxygen in steel. The results obtained so far indicate that the amount and state of the carbon present have an influence on the iron-oxide fraction of the residue. Normalised high-carbon steels give iron oxide fractions which are much greater than would be expected. Furthermore, all the steels containing more than 0·45 per cent. of carbon, examined in the quenched condition, give higher iron oxide fractions than in the normalised condition. Steels containing less than 0·45 per cent. of carbon appear to give the highest value for the iron oxide fraction after spheroidisation. An interesting feature of the work is that the P_2O_5 fraction of the residue is always greater in the quenched steels than in those which are normalised. The lowest values were always obtained from the spheroidised samples.

Of the two remaining sections of the report, Section X is an able general summary of all the preceding sections, prepared by the Chairman, Dr. T. Swinden. He emphasises and briefly comments upon the main points brought out by the various research workers. Section XI contains an account of the work in hand and the future programme, wherein it is stated that research must continue until metallurgists are able to determine with complete accuracy the oxygen in its various forms of occurrence in the inclusions, or, in fact, in the steel itself. It would seem sometimes that the residue methods employed to achieve this end tend to become more and more complicated, and to be relegated to a position in the research laboratories rather than in the routine steelworks laboratory. It may be hoped, however, that in due course, when the limitations are more fully explored, simple modifications of the alcoholic iodine and/or chlorine methods will result in the present difficulties being eliminated. It is hoped and anticipated that the happy collaboration with the British Cast Iron Research Association will continue, and that further light will be thrown upon the question of non-metallic inclusions in pig and cast irons.

INSTITUTION OF ELECTRICAL ENGINEERS AWARDS.

THE Council of the Institution of Electrical Engineers has made a number of awards of premiums in respect of papers read during the 1940-41 session, or accepted for publication. These include the award of the Institution Premium to Mr. C. F. Booth; of the Ayrton Premium to Mr. W. A. Cook, B.Sc. (Eng.); of the Fahie Premium to Messrs. A. Fairweather, M.Sc., and J. Ingham, M.Sc.; of the John Hopkinson Premium to Mr. G. H. Rawcliffe, M.A.; and of the Kelvin Premium to Messrs. C. E. R. Bruce and R. H. Golde. In addition, extra premiums have been awarded to Mr. C. G. Garton, to Messrs. L. Gosland, B.Sc., and W. F. M. Dunne, B.Sc., to Professor Willis Jackson, D.Sc., and Mr. A. E. Chester, M.Sc., to Dr. R. Jessel, to Messrs. W. J. Mason and S. A. G. Emms, to Mr. G. H. Metson, M.Sc., B.Sc. (Eng.), and to Mr. A. Langley Morris. In the Wireless Section, the Ambrose Fleming Premium has been gained by Messrs. N. M. Rust, O. E. Keall, J. F. Ramsay, M.A., and Dr. K. R. Sturley, B.Sc. Other Premiums in this Section have been awarded to Messrs. C. A. Mason, B.Sc. (Eng.), and J. Moir, and to Dr. R. H. Barfield. Premiums in the Meter and Instrument Section have been awarded to Dr. A. E. W. Austen, B.Sc., and Dr. S. Whitehead, M.A., and to Messrs. A. J. King, B.Sc. Tech., and C. R. Maguire, B.Sc., and Dr. R. W. Guelke and Dr. R. A. Scott. The Sebastian de Ferranti Premium in the Transmission Section has been gained by Mr. F. R. Perry, M.Sc. Tech., while another Premium in this Section has been awarded to Dr. C. Dannatt and Mr. R. A. Polson, B.E. The awards made in respect of papers read before the Students' Sections will be announced at a later date.

AIR FILTERS.

THE importance of supplying dust-free air for internal-combustion engines, air compressors, generator ventilating systems and so forth, as well as in air-conditioning for certain industrial processes and places of public assembly, is now so fully recognised that the manufacture of filtering appliances is a considerable branch of engineering. Examples of such appliances, which all employ an interesting means of ensuring dust-interception, are described below, and one of them is illustrated in Figs. 1 and 2, on this page. They are made at the Warrington works of Messrs. Air-Maze (Great Britain), Limited, Bush House, Aldwych, London, W.C.2. The filter shown in the figures is the firm's oil-bath type for engine and compressor air inlets, and shows, in Fig. 2, that the screen consists of alternating layers of flat wire mesh and wire mesh corrugated into angular folds. In this particular example the screen consists of eight layers, six of flat wire mesh and two of corrugated wire mesh, but the fact that the meshes are of different type does not emerge. The arrangement may, however, consist of a flat mesh with the wires arranged at right angles, as in an ordinary sieve, while the other flat meshes may have the wires arranged diagonally at different angles in each mesh. The result is that the passages through the screen are very tortuous or maze-like, a condition from which the manufacturing firm takes its name.

The particular type of which the inner construction is shown in Figs. 1 and 2, is the normal standard oil-bath type, but the filter is also manufactured with an integral silencer, a fitting which alters its proportions

Fig. 1.

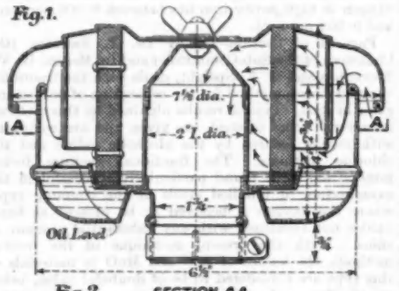
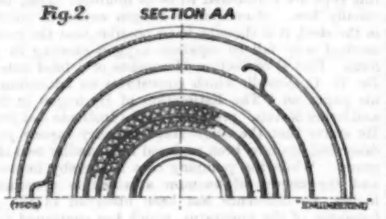


Fig. 2. SECTION AA



somewhat. To give some idea of the capacity provided, it may be stated that the filter shown in Figs. 1 and 2 has a capacity up to 50 cub. ft. per minute; and a filter with an overal diameter of 14½ in. and a height of 11¾ in., has a capacity up to 750 cub. ft. per minute; while a filter with a silencer and having a capacity up to 500 cub. ft. per minute, has a height of 10½ in. and an external diameter of 11 in. An alternative method of attachment, viz., a flanged connection, as opposed to the circular clip arrangement in Fig. 1, may be used. The air cleaning efficiency of the oil-bath type is claimed to be 99 per cent., and the pressure drop due to air flow to be only 1½ in. water gauge. The disposition of the layers shown in Fig. 2, however, is not invariable, this being cited only as a typical example. As a matter of fact, the screens can be made up in a variety of ways, in some cases a much greater number of corrugated layers being fitted. The construction in all the filters, we understand, is approved as an efficient flame trap and is sufficiently quiet in operation for all normal purposes, though, as indicated above, a silencer can be incorporated if desired.

As regards construction, the filter body is made of spun sheet mild steel finished with a glazed aluminium enamel. The filter element is of fine galvanised steel wire. Referring to Fig. 1, it will be seen that the lower part of the body consists of a neck, an internal tube, and a bowl, all three parts being spot-welded together. The bowl is formed with a bead to indicate the level to which the oil is to be filled. The tube has a bridge across the top, in which the bolt used for holding down the cover is welded. The neck is slotted at intervals to allow for compression under the screw clip. The upper part of the filter consists of a flanged cover, this flange being of different depths, according to the conditions under which the filter has to be employed. A sleeve on the underside of the cover projects downwards to a little distance above the oil level and carries on the outside a number of vanes disposed in an approximately helical fashion. The vanes are of roughly semicircular cross-section, as shown in Fig. 2, and their function, in addition to centring the cover, is to impart a swirl to the entering air, which follows the direction indicated by the arrows on the right of Fig. 1. All the upper parts are spot-welded together. The several layers of the filter element are connected by through-rivets. Its bottom edge rests on a flanged baffle plate pierced on the bottom with holes. The baffle plate rests on a shoulder of the bowl, but is otherwise loose so as to offer no obstacle to the cleaning of the bowl.

The dust is largely intercepted in the oil-bath filter by being entrapped by the oil film on the element and by being forced to pass over the surface of the oil contained in the bowl. Any inexpensive motor crankcase oil will serve. In course of time sludge naturally accumulates in the bowl, which should then be cleaned out and re-filled with fresh oil. The filter element is cleaned by agitation in thin waste crankcase oil, and replaced after draining. Alternatively, steam or compressed air may be used for cleaning. The corrugated layers in the element greatly facilitate cleaning, and it is stated that the whole of the dirt can be dislodged. Apart from this, premature clogging cannot take place, as the filter element is arranged so as to present greater density on the inner surface, since the larger particles are intercepted when the air first strikes and enters the element. The element is capable of withstanding vibration. The oil-bath type of filter is made in different sizes to provide a range of capacities up to 750 cub. ft. of air per minute.

Another type of filter, known as the "Unimaze" filter, has the same type of element, but this is not enclosed, the filter externally having the appearance of a flat top and bottom disc with the element between. The air cleaning efficiency of this type is claimed to be 99 per cent., and the initial pressure drop due to air flow to be as low as ½ in. water gauge. This type is made with a range up to 1,000 cub. ft. of air per minute, the smallest, with a capacity up to 25 cub. ft. per minute, being 2¾ in. in diameter by 2¾ in. high, and being suitable for small engines, such as are employed on motor cycles. The principle is also incorporated in a series of panels for use in air conditioning plants, cooling installations, furnace blower cabinets, window ventilators, etc. These panels are known by the trade name of "Kleenflo," and are claimed to give a cleaning efficiency of from 98 per cent. to 99·6 per cent., as well as a very long life between cleanings, due to the large area presented, the elements chiefly consisting of corrugated layers of graduated depth and pitch. The capacity naturally varies with the size of panel, which is made to commonly-accepted standard sizes; the recommended capacity is from 1·5 cub. ft. to 2·5 cub. ft. per minute per square inch of panel surface. Cleaning is effected by agitation in hot water or under a stream of hot water, and recharging is effected by spraying or immersion in any inexpensive motor crankcase oil.

PEDESTRIAN CROSSINGS ON HIGHWAYS.—The Minister of Transport has issued the Pedestrian Crossing Places (Traffic) Regulations, 1941. This states that a driver must proceed at such a speed as to be able to stop if necessary before reaching such a crossing, unless he can see that there is no person on it. On any crossing where traffic is not, for the time being, controlled by a police constable or light signals, the driver must allow free passage to any pedestrian who is on the carriageway at such crossing. Where the crossing is controlled, any pedestrian who has started to pass over before the driver receives the proceed signal must be allowed free passage. Halting on crossings, except to avoid accidents or on account of circumstances beyond the driver's control, is not permitted. Pedestrians, however, are informed that they must not linger on crossings.

CONTROL OF IRON AND STEEL.—The Ministry of Supply has issued Direction No. 3 under the Control of Iron and Steel (No. 8) Order, 1940. This deals with iron castings, and under paragraph 1 of the new Direction, maximum prices for iron castings in the form of rainwater and soil goods, gutters and connections, which are usually known as 'builders' ironwork, are increased to 21 per cent. above the basis prices in the deposited schedules. This represents an increase of 2½ per cent. on the prices ruling previously and is based on increases in the costs of wages and fuel. Paragraph 2 of the Direction restricts to ¼ cwt., or 10*l.* in value, the maximum quantity of iron castings which any person may buy without licence in any week. The previous limit was 5 cwt., or 10*l.* in value, and this further restriction arises from the necessity of conserving supplies of iron. Copies of the new Direction may be obtained, price 1*d.* net, from H.M. Stationery Office, York House, Kingsway, London, W.C.2.

LABOUR NOTES.

THE Railway Staff National Tribunal has issued its award on the claim of the railwaymen's trade unions for increases of wages. The National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen and the Railway Clerks Association had jointly applied to the railway companies for an advance, as from November 22 last, of 10*s.* a week for adult male staff in the traffic grades and 26*l.* a year for adult male clerical, supervisory and other salaried staff. The Tribunal's award provides that from January 6, 1941, the existing special war advances shall be increased by 4*s.* a week in the case of adult male wages staff (making a total war advance of 11*s.* a week) and by 10*l.* a year in the case of adult male clerical, supervisory and other salaried staff (making a total war advance of 28*l.* a year), with proportionate increases for females and juniors.

The executive committee of the Mineworkers' Federation has decided to apply, on behalf of the members of its constituent associations, for a minimum weekly wage of 4*l.* Mr. Edwards, the secretary of the Federation, stated on Friday last week that the matter would be discussed with the coalowners probably this week.

During April, the home branch membership of the Amalgamated Engineering Union increased from 477,768 to 487,098, and the Colonial branch membership from 42,556 to 43,860. The number of members in receipt of sick benefit decreased from 5,967 to 5,145, and the number of superannuated members from 13,327 to 13,310. The number of members in receipt of donation benefit decreased from 465 to 340, and the total number of unemployed members from 2,048 to 1,839.

Mr. Tanner, the president of the Amalgamated Engineering Union, states, in the May issue of the organisations *Journal*, that at a recent meeting, the Railway Shopmen's Council considered a proposal by the railway companies to apply to the industry the Essential Work (General Provisions) Order, 1941. After discussing the matter, the Council agreed—"on the understanding that the machinery of the Shopmen's Council is retained for negotiation purposes."

The writer of the editorial notes in the same issue of the *Journal* says that "problems of peculiar complexity are arising as a consequence of the introduction of women in many skilled processes." "Under the pressure of necessity," he continues, "the employment of women is extending beyond the operation of capstans, milling and drilling machines, inspections and light assembly work. . . . Women operators are being employed in aircraft factories on a number of precision processes, on welding jobs, in the operation of boring and grinding machines, and on work of a non-repetitive character. We are bound as a union to take account of these developments, not only during the period of war emergency, but with an eye to the future, when peace comes again. It is of the utmost importance, therefore, to maintain union functions in relation to all those problems of management. That is the union's policy in these difficult days."

The latest *Trade Report* of the United Patternmakers' Association states that in April the membership of the organisation increased from 12,749 to 12,787. The number of members in receipt of trade benefit was 39—a decrease of four compared with the position a month earlier—and the number in receipt of sick benefit 290, compared with 327. The number of superannuated members was 676, an increase of two.

The annual report of the United Patternmakers' Association shows that in 1940 the gross income was 74,718*l.* 11*s.* 10*d.*, and the gross expenditure 52,439*l.* 5*s.* 10*d.* Of the income, 8,430*l.* 5*s.* 11*d.* represented National Health Insurance benefit and 3,133*l.* 16*s.* 2*d.* State Unemployment benefit, and of the expenditure, 9,056*l.* 13*s.* represented National Health Insurance benefit and 3,211*l.* 12*s.* 11*d.* State Unemployment benefit. The net trade union income was 64,626*l.* 6*s.* 6*d.*—an increase of 993*l.* 8*s.* 11*d.*—and the net trade union expenditure 40,246*l.* 17*s.* 2*d.*—a decrease of 309*l.* 1*s.* 7*d.*

The number of trade disputes involving stoppages of work, reported to the Ministry of Labour and National Service as beginning in March, was 121. In addition, eight disputes, which began before March, were still in progress at the beginning of that month. The approximate number of workpeople involved in these 129 disputes (including workpeople thrown out of work at the establishments where the disputes occurred) was 63,000, and the aggregate duration of the disputes in March was about 285,000 working days.

The General Council of the Trade Union Congress is organising a further series of conferences which will have the object of explaining the principal phases of the activity in which Labour is taking part in support of the war effort. The following centres have been chosen provisionally as possible venues, and final decisions as to places and dates are to be communicated to unions as soon as possible:—Preston, Leeds, Birmingham, Northampton, South Wales and Gloucester. It is hoped that when places and dates have been fixed, the attendance of full-time officials and representatives of branches within 15 miles of the selected centres will be authorised by the unions. The expectation is that unions will arrange meetings of their members, either directly or through district committees, for the dual purpose of transmitting to them the information given at the conferences and dealing with other matters which are of special interest and concern to their members.

Discussing the eighth annual report of the Unemployment Insurance Committee, the writer of the editorial notes in the May issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation, claims that, apart from post-war considerations, improvements are needed, "particularly the abolition of the three days waiting period and the continuity rule." "We have never," he says, "been able to understand the need for a waiting period, unless it is based on the idea that a man should live for three days without any means so as to accustom himself to the kind of existence he will enjoy when on benefit. It is about time that we swept all these relics and hangovers of the cheese-paring and pauperising age of Bumbledom into the dustbin of their miserable past, and we hope that the Committee, when considering the abolition of the waiting period, as requested by the T.U.C., will decide in a way in keeping with the age we are living in."

According to Mr. Witt Bowden of the American Bureau of Labour Statistics, average hourly earnings rose significantly in the United States in 1940. The increase was only, he says, in a minor part, a result of higher rates of pay. Important factors were an increase in the amount of overtime at overtime rates and a rise in the proportion of workers in high-wage industries. Overtime, which increased notably in defence industries, contributed to higher weekly earnings. Employment, hours, pay rolls and *per capita* consumption increased, but many unemployed workers remained available for employment, not only for defence production, but also in the consumption goods and service industries.

A survey of the extent of week-end "shut-downs" in 394 large establishments in 11 key defence industries made by the American Bureau of Labour Statistics shows that almost one-half of the plants were operating at least six days a week. Overtime was widespread—approximately 280,000 wage-earners worked more than two and a half million hours of overtime during the middle week of December, 1940. Overtime per worker for the week ranged from slightly less than five hours in the explosives and smelting and refining industries to more than 11 hours in the shipbuilding, firearms and machine-tool industries. More than half of the plants were operating 5 or 5½ days per week. Although over 80 per cent. of the plants were making use of multiple-shift operating schedules, only 25 per cent. of the workers in these plants were engaged on other than the main shift.

The March *Review* of the International Labour Office—which is now, as has been mentioned in these Notes, operating from Montreal—states that an Act which came into force in Spain in October last made permanent the system of Labour Courts introduced provisionally by an Order issued in May, 1938. The system, which is placed under the supervision of the Department of Labour, provides for at least one Labour Court in each province and a National Court to hear appeals against decisions of the provincial Labour Courts. Each provincial court includes one labour judge, while the National court is composed of five members—a chairman, who is the General Director of Labour Courts, and four judges appointed by the Department of Labour. The courts are competent to deal with all disputes between employers and wage-earning or salaried employees engaged in industrial production, and are empowered to take cognisance not only of matters of civil jurisdiction, but also of matters of a penal character resulting from "actions injurious to the established economic order or incompatible with the honour which should be shown in the daily relations between employers and employees."

CONDENSING PLANT AND COOLING WATER SYSTEMS.*

By W. T. BOTTOMLEY, A.R.T.C.

IN the generation of electric power by steam turbine, considerable attention has been given to the improvement in economy to be effected by increasing the initial steam temperature and pressure, and by adopting progressive feed heating and interstage reheating. Little attention, however, has been given recently to the economy to be effected at the lower temperature limit of the thermal cycle, which is the average temperature at which the heat is extracted from the working medium in the condenser. The only important paper within the last decade or two on the subject of condenser design is that given by Guy and Winstanley in 1934.† Except for the substitution of the steam ejector for the reciprocating air pump, and better design of the steam passage through the condenser to reduce the pressure drop and recover the velocity head, it would appear that the condensers of to-day show little improvement on those of 20 years ago. Indeed, it might be said that the same rule of thumb is still adopted for determining the size of condenser and quantity of circulating water, namely, 6 lb. or 7 lb. of steam condensed per square foot of condenser surface per hour at economical load, with circulating water 70 to 80 times the quantity of steam condensed. These rules are for land practice. For marine practice the rule for the quantity of water is apparently the same, but the steam condensed per square foot of surface is considerably greater and depends on the type of ship. The author's firm has made a practice for a number of years of specifying 6 lb. of steam per square foot, although manufacturers would consider 7 lb. to 7½ lb. per square foot satisfactory; yet, in spite of this, general requests have been received from operating engineers in this country and abroad for larger condensers. On the other hand, we have to consider the desire of authorities to keep down the initial cost to the minimum consistent with economy. The relation between the normal vacuum in the condenser and the average temperature of the inlet circulating water has been more or less fixed by convention. Thus, 29-in. vacuum is specified when the average inlet circulating-water temperature is 55 deg. F., and, in special cases, when the water temperature is 60 deg. F.

The performance for wooden cooling towers were also specified on conventional lines. The normal re-cooled water was specified at 77 deg. to 80 deg. F., for which a normal vacuum of 28 in. was expected. Due to the improved efficiency of the hyperbolic concrete tower, however, there appears to have been a tendency to base the specified normal performance on economical grounds, ascertained by trial-and-error methods. Mr. Lawton states in his paper on Hams Hall‡: "It will be found that the condenser design and the cooling-tower size are so fundamentally related that it is impossible to decide on one without reference to the other." The author understands that for Hams Hall about 50 schemes were considered before a decision was made.

TABLE I.

1937.	Average for March.	Average for August.	Yearly Average.
	Deg. F.	Deg. F.	Deg. F.
Condensate temperature ..	45·5	74·4	57·5
Circulating water inlet ..	34·1*	63·6†	45·7
Difference	11·4	10·8	11·8
Temperature rise of water ..	4·2	4·0	4·1
Final temperature difference	7·2	6·8	7·7

* Coldest monthly average inlet temperature.
† Hottest monthly average inlet temperature.

In the United States the size of condenser is not out of the ordinary, but the quantity of water sometimes exceeds anything we have in this country. Port Washington power station (U.S.A.) is the most efficient power station in the world, and monthly and yearly average operating figures have been published from time to time. The figures for 1937, in Table I, herewith, have been taken from *Combustion*, February, 1938, the average load being nearly steady at 53,000 kW and generated by one machine. The temperature rise of

* Paper entitled "The Economics of the Design of Condensing Plant and Cooling-Water Systems as Applicable to Power Stations," read before the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne, March 28, 1941. Abridged.

† "Some Factors in the Design of Surface Condensing Plant," by Dr. H. L. Guy and E. V. Winstanley, *Proc. I.Mech.E.*, vol. 126, page 227 (1934).

‡ "Design and Operation of Hams Hall Power Station," by F. W. Lawton, *Proc.I.E.E.*, vol. 85, page 487 (1939).

the circulating water of 4 deg. F. shows that the quantity of circulating water is nearly 250 times the quantity of steam condensed.

The theoretical lower-temperature limit of the thermal cycle is the temperature of the water in the river for river-water cooling; for cooling-tower schemes, it is the atmospheric wet-bulb temperature. On the average throughout the year, these two temperatures are about the same in a given locality, *i.e.*, about 52 deg. F. in this country. The approach of the condensing temperature to the theoretical temperature is limited by the question of cost, and the aim should be to design the plant so that the total annual cost, including capital charges, is a minimum. It can be proved that for conditions of minimum cost, the size of the condenser, the size of the tower and the quantity of circulating water are each determined independently of the other two.

Section I.—The cost of power plant in general, as affected by the design of the condensing plant, the circulating-water system and cooling towers if cooling towers are used, is directly dependent on five variables. These are the condenser surface S; the quantity of circulating water G; a dimension depending on the size of the tower F, if towers are used; the power absorbed by the circulating-water pumps P; and the vacuum temperature at the top of the condenser T. This is expressed mathematically as follows:—

Cost = C = f (S, G, F, P, T), where f represents any function.

The condition to be satisfied for minimum cost is obtained by differentiating and equating to zero:—

$$d\,C = \frac{\delta C}{\delta S} d\,S + \frac{\delta C}{\delta G} d\,G + \frac{\delta C}{\delta F} d\,F + \frac{\delta C}{\delta P} d\,P + \frac{\delta C}{\delta T} d\,T$$
$$= Z_S\,d\,S + Z_G\,d\,G + Z_F\,d\,P + Z_P\,d\,P + Z_T\,d\,T$$
$$= 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where Z_S Z_G, etc., represent the increase in cost per unit increase in the variable with which each is connected, *i.e.*, S, G, etc., assuming that the other four variables are constant. When equation (1) is applied to a given set of conditions and represents average annual conditions, there will be only three independent variables S, G and F. The variables P and T representing the power for pumping and the vacuum temperature are not independent, but depend on the other three; that is to say,

$$d\,P = \frac{\delta P}{\delta S} d\,S + \frac{\delta P}{\delta G} d\,G + \frac{\delta P}{\delta F} d\,F$$

and

$$d\,T = \frac{\delta T}{d\,S} d\,S + \frac{\delta T}{\delta G} d\,G + \frac{\delta T}{\delta F} d\,F.$$

Substituting these differentials in (1) and re-arranging the terms, the condition for minimum cost is given by:—

$$d\,C = \left\{ Z_S + Z_P \frac{\delta P}{\delta S} + Z_T \frac{\delta T}{\delta S} \right\} d\,S$$
$$+ \left\{ Z_G + Z_P \frac{\delta P}{\delta G} + Z_T \frac{\delta T}{\delta G} \right\} d\,G$$
$$+ \left\{ Z_F + Z_P \frac{\delta P}{\delta F} + Z_T \frac{\delta T}{\delta F} \right\} d\,F$$
$$= 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

But $d\,S$, $d\,G$ and $d\,F$ represent any arbitrary change and are not nil; therefore, the expressions in each bracket must be nil independently. That is to say,

$$Z_S + Z_P \frac{\delta P}{\delta S} + Z_T \frac{\delta T}{\delta S} = 0 \quad . \quad . \quad (3A)$$

$$Z_G + Z_P \frac{\delta P}{\delta G} + Z_T \frac{\delta T}{\delta G} = 0 \quad . \quad . \quad (3B)$$

$$Z_F + Z_P \frac{\delta P}{\delta F} + Z_T \frac{\delta T}{\delta F} = 0 \quad . \quad . \quad (3C)$$

Equations (3A) and (3B) apply to river-water cooling, and all three apply to cooling-tower schemes.

It will be shown later in Sections II and III that:—

$$\frac{\delta T}{\delta S} = -\frac{W}{S^2} \frac{R}{m} \quad . \quad . \quad . \quad \text{see Eq. (14)}$$

$$\frac{\delta T}{\delta G} = -\frac{W}{0{\cdot}6\,G^2} \left(\frac{m-a}{m} \right) \quad \text{see Eq. (15)}$$

$$\frac{\delta T}{\delta F} = -\frac{1}{1{\cdot}1} \frac{W}{F^2} \quad . \quad . \quad \text{see Eq. (28)}$$

where W represents the load on the condenser and R the overall thermal resistance, and it will be noticed that the value of each differential in one variable is independent of the other two variables.

It will be shown also that $\frac{\delta P}{\delta S}$ is constant for a fixed water velocity in the tubes and that $\frac{\delta P}{\delta F}$ is nil. The value of $\frac{\delta P}{\delta G}$ for economical velocity in the circulating-water pipes can be treated as constant within the range of water quantities considered.

Therefore, the solutions of equations (3) are given by:—

$$\frac{W}{S} = \sqrt{\frac{Z'_S}{Z'_T} \frac{m}{R}} \quad . \quad . \quad . \quad . \quad . \quad (4A)$$

also

$$x = \frac{W}{0{\cdot}6\,G} = \sqrt{\frac{Z'_G}{Z'_T} \frac{m}{0{\cdot}6\,(m-a)}} \quad . \quad (4B)$$

and

$$\frac{W}{F} = \sqrt{\frac{Z_F}{Z'_T} \times 1{\cdot}1} \quad . \quad . \quad . \quad . \quad (4C)$$

where

$$Z'_S = Z_S + Z_T \frac{\delta P}{\delta S}$$

and

$$Z'_T = \frac{Z_T}{W}$$

$$Z'_G = Z_G + Z_T \frac{\delta P}{\delta G}.$$

It will be noticed from equation (4) that the value of each variable for conditions of minimum cost is determined independently of the other two variables.

Fig. 1.

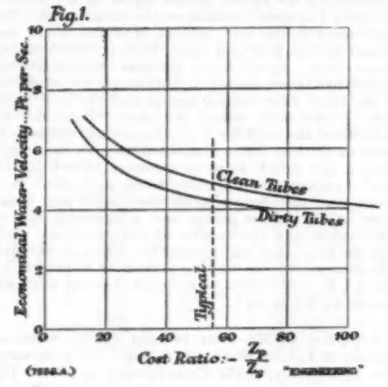


Fig. 2.

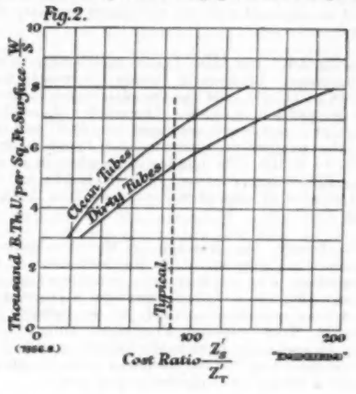


Fig. 3.

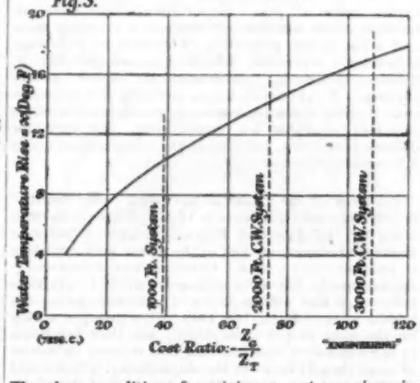
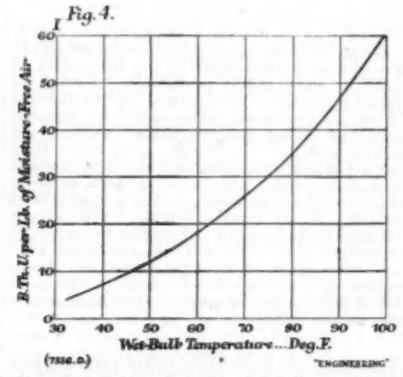


Fig. 4.



The above conditions for minimum cost are given in terms of fixed water velocities. The water velocities should, however, be the economical velocities. The economical water velocity in the condenser tubes is given by equation (22) in Section II.

The economical velocity of the water in the condenser tubes is shown in Fig. 1, herewith, in terms of a cost ratio, the ratio being the capitalised value of the cost of power for pumping per kilowatt to the capital cost of extra condenser surface per square foot. Two curves are given, one for clean tubes and the other for average dirty conditions. A dotted line shows a typical case. It will be seen that the economical velocity is less than 5 ft. per second. The author has been informed on several occasions by condenser manufacturers that the economical velocity is about 7 ft. per second, and in the United States a velocity of 7 ft. or 8 ft. per second is considered the most economical. It has been suggested that the higher velocity will keep the tubes cleaner and, while this may be true, it is difficult to prove it. Care, however, should be taken in designing the water boxes when using low velocities, so that the water should be distributed as evenly as possible in the different tubes and that there should be no reversal of flow.

The condition for economical condenser surface is shown in Fig. 2, on this page, and is given in the form of thousand B.Th.U. per square foot of internal surface of the tubes per hour, or approximately the lb. of steam condensed per square foot of surface per hour, against a cost ratio $\frac{Z'_S}{Z'_T}$, where Z'_S represents the cost of extra condenser surface per square foot (internal tube surface), including the capitalised value of the cost of pumping against the head across the condenser, and Z'_T represents the capitalised value of the annual loss due to raising the vacuum temperature 1 deg. F. per 1,000 B.Th.U. extracted per hour. The cost of pumping depends on the velocity through the tubes, but is independent of the total quantity of circulating water. Two curves are given, one for clean tubes and the other for average dirty tubes. A dotted line is shown representing a typical condition met in practice in this country, and it will be seen that the loading of the condenser should be about 5 lb. of steam per hour per square foot of surface under normally dirty conditions, assuming a water velocity of 5 ft. per second through the tubes. The formula for the curve in Fig. 2 is given in equation (4A). It would appear from Fig. 2 that a liberal design of condenser is justified.

The quantity of circulating water depends on the length of the circulating-water system and the amount of static lift. The condition for minimum cost is represented in Fig. 3, on this page, where the quantity of circulating water is indicated by the temperature rise through the condenser. The results are plotted against a cost ratio $\frac{Z'_G}{Z'_T}$, where Z'_G represents the cost of the circulating-water system per extra gallon per minute of water, including the capitalised value of the cost of pumping through the system (apart from the condenser) and including the cost of pumping against the static lift. The latter item is important when towers are used. Dotted lines are shown in the figure showing typical cost ratios for river-water cooling for circulating water systems of 3,000 ft., 2,000 ft. and 1,000 ft. in length, excluding the loss of siphon head. The dotted line for 2,000 ft. also represents the condition for a cooling-tower scheme having a static lift of 30 ft., in conjunction with a circulating-water system of 1,000 ft. The economical cooling range for the tower in this instance is 14 deg. F., and it will be noted that the cooling range for the tower is not dependent on the size of the tower. Fig. 3 shows for river-water schemes that, the longer the circulating-water system, the less should be the quantity of water used. Since the temperature rise of the water is higher for longer systems the normal specified vacuum should be lower, but the increase in the vacuum temperature is not equal to the increase in the water temperature rise, but is only 61·5 per cent. of it in accordance with equation (13), given later.

Some difficulty has been experienced in finding a basis for determining the economic size of cooling

towers and the corresponding value of the cooled water temperature, partly because the various corrections received are inconsistent and partly because there does not appear to be a generally accepted theory for the performance of towers. Some papers have been given by Mr. Gueritte,* but they do not produce a theory for the present purpose. Several papers have been published in the United States,† but the author has found that the theory developed by Merkel‡ in Germany is the most rational and agrees closely in form with test results.

Merkel showed that the transference of heat from wetted surfaces to the surrounding air per square foot of wetted surface is proportional to the difference between the heat content of saturated air at the temperature of the wetted surface, per lb. of moisture-free air, and the heat content of the cooling air. The heat content of air is shown in Fig. 4, opposite, for different wet-bulb temperatures. The transfer of heat is also proportional to the coefficient of heat transfer for dry air which depends on the air velocity. From this a performance coefficient is obtained for the overall cooling in a tower, which is connected with the rainfall at the base of the tower by a straight-line relation, the two constants for which are determined from the published performances of the towers at Hams Hall* at Birmingham and Klip in South Africa.†

From this curve the conditions for minimum cost have been found, and results are given in Fig. 6, below, which shows the loading per square foot of base area plotted against a cost ratio $\frac{Z_T}{Z'_T}$, where Z_T is the cost of the tower per square foot of base area. The curve also shows the corresponding re-cooled water temperatures for average wet-bulb temperatures of 52 deg. F. The position marked by the dotted line represents a typical cost ratio obtained in a base load station, indicating that it is reasonable to expect an average re-cooled temperature of 72 deg. F. when the wet bulb is 52 deg. F., the ratio $\frac{W}{F}$ being 14. This, in conjunction with 14 deg. F. cooling range already suggested, indicates that the economical rainfall at the tower base should be 100 gallons per hour per square foot.

It is apparent from Figs. 2 and 3 that, although the length of the circulating-water system does not affect the economic surface area of the condenser it does affect the economic ratio of the water quantity to condenser surface and therefore affects the number of passes and the length of tubes. From the equations for Figs. 2 and 3 it will be found that the economic ratio of water to surface is independent of the vacuum temperature. The ratio is shown in Fig. 7, herewith, plotted against the cost ratio $\frac{Z'_S}{Z'_S}$, both costs including the cost of pumping. Two curves are given, one for clean tubes and the other for normally dirty tubes. Dotted lines show typical conditions for circulating-water system lengths of 3,000 ft., 2,000 ft. and 1,000 ft., corresponding to those shown in Fig. 3. The formula for the curves in Fig. 7 is :—

$$\frac{G}{S} = \sqrt{\frac{Z'_S}{Z'_G} \times \frac{(m-a)}{0{\cdot}6\,R}} \quad . \quad . \quad (4D)$$

The economic ratio of the water to condenser surface, in conjunction with a fixed water velocity through the tubes, determines the number of passes and the length of tubes ; the relation is given by the following equation :—

$$\frac{pl}{d} = 7{\cdot}8\,v\,\frac{S}{G} = 4{\cdot}68\,\frac{v\,x}{\frac{W}{S}} \quad . \quad . \quad (5)$$

For a tidal circulating-water system of over 2,000 ft., or for cooling towers, the economic ratio of $\frac{G}{S}$ is about 0·6, and if the velocity is taken at 5 ft. per second the economic value of $\frac{pl}{d}$ is 65. As the tidal river is usually dirty and some cooling towers use sewage effluent, it is preferable to use tubes 1 in. in outside diameter and of No. 18 s.w.g. for which $d = 0{\cdot}902$ in. For any but the largest machines, this condition requires a four-pass condenser with a length of tube of nearly 15 ft. With three passes the tube length is nearly 20 ft., and is too long for machines of less than 20,000 kW.

Since most power stations in this country use tidal river water or cooling towers, this condition, which requires a four-pass condenser, arises frequently, but the usual standard condensers supplied by manufacturers are either two- or three-pass, and to convert them to four-pass would increase the cost per square foot. The other alternative is to increase the quantity of water beyond the economic limit, but this also would add to the cost. The author suggests that this difficulty should not arise and that the standard design of condenser should, if possible, be made more suitable for the usual conditions met with in practice. The condensers at Carville "B" power station have four passes and are considered satisfactory.

At the other end of the range there is the condition for the single-pass condensers for large machines. This condition is justified when the power station is placed on the river front of a non-tidal river and the length of the circulating-water system is short enough to justify an economical water-temperature rise of under 6 deg. F. Particulars of tests carried out on a single-pass condenser are given in a paper by G. H. Van Hengel.* The tubes were 1 in. outside diameter and 23 ft. 9 in. between tube plates. The performance of this condenser, however, does not appear to be so good as that at Port Washington, because the difference between the condensate temperature and the circulating water outlet temperature is about 12 deg. F., as compared with 7 deg. F. at Port Washington. Also, it is not able to take full advantage of low water temperatures.

The cost per sq. ft. of condenser surface (Z_S) is usually given as 10s. to 12s. per sq. ft. and includes the effect of increasing the surface on the outer casing and end doors, tube plates, etc. ; but the size of the condenser affects the size of the turbine house. If the turbines are placed transversely in the building the spacing of the machines is affected by the length of tubes, while if the turbines are placed longitudinally the width of the building must be sufficient to allow for tube withdrawal. The extra volume of building space and the cost will depend on the size of the plant ; the author assumed 6s. per sq. ft. of surface for the effect on the building and 12s. per sq. ft. for the increase in the cost of the condenser, making 18s. total for Z_S. The prices are all pre-war prices, but the rise in prices now should not materially affect the ratios.

The cost of pumping power per kW (Z_P) will depend on individual conditions and average loading. It was assumed that the pumps, including standby, would be running at full power for 50 per cent. of the time, *i.e.*, 4,380 hours per annum on the average, or 4,380 kWh per kW per annum. It is debatable whether the cost per unit should be only the cost of fuel or should include the total cost of generation in bulk. The latter has been assumed, taking 0·22*d.* per unit, giving 4*l.* per kW per annum. Capitalised at 10 per cent., this gives 40*l.*, which is brought up to 50*l.* per kW to include the cost of the pump and motor.

The kW for pumping across the condenser is $\left(\frac{v}{36}\right)^3$ per sq. ft. of condenser surface. At 5 ft. per second and 50*l.* per kW, the cost of pumping is 2*s.* 8*d.* per sq. ft. of condenser surface, which, added to 18*s.* for Z_S, gives 20*s.* 8*d.* per sq. ft. for Z'. However, a round figure of 20*s.* was assumed in Fig. 2. The cost of the pipe work per 1,000 ft., including pumping at constant velocity, plotted against the gallons per minute, gives approximately a straight line not passing through zero. The slope of the line gives a rate of 8*s.* per 1,000 ft. per gallon per minute at the economical velocity, about 6 ft. per sec. ; of this 1·6*s.* is the cost of pumping. To this must be added the cost of at least four valves, which total about 1*s.* per gallon per minute. The cost of pumping against a static lift due to loss of siphon, or due to the lift to the hot-water trough of the cooling tower at 50*l.* per kW, amounts to 3*s.* per 10 ft. lift per gallon per minute. The cost of a 30-ft. lift to the cooling tower is, therefore, about the same as the cost of 1,000 ft. of circulating-water system on the level, including the cost of pumping.

The pre-war cost of cooling towers (Z_T) appears to be about 32*s.* to 42*s.* per extra sq. ft. of base area, depending on the size of the tower. The higher cost rate applies to the large towers. The value of 1 deg. F. of vacuum temperature depends on the normal vacuum. The extra kW output due to improvement in vacuum should offset the extra kW for pumping, and should be valued at the cost of power, *i.e.*, 40*l.* per extra kW. It is assumed that the turbine-exhaust area will if possible be increased with the improved normal vacuum, and vice versa, in order to keep the percentage leaving losses constant. To allow for this the cost per kW due to varying the vacuum temperature was reduced to 30*l.* It is assumed that, at constant leaving loss, the extra kW obtained for one deg. improvement in vacuum temperature is 0·25 per cent. of the kW output of the machine at economical load ; therefore, the value of Z_T is 1*s.* 6*d.* per kW output of the machine at economical load. Z'_T is the corresponding cost per unit W and the value of Z'_T assumed for the figures is for W = 6·5 per kW, which represents an efficient machine of 30,000 kW, C.M.R., 3,000 r.p.m., supplied with steam at 600 lb. gauge and 800 deg. F., and having progressive feed heating.

Considerable departure of the variables surface

Fig. 5.

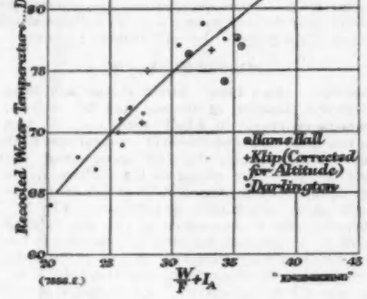


Fig. 6.

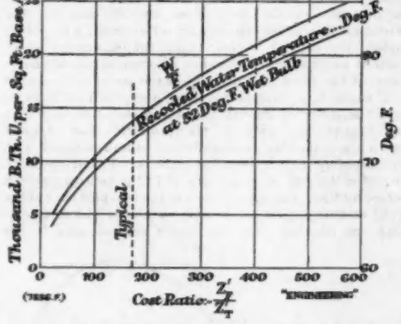
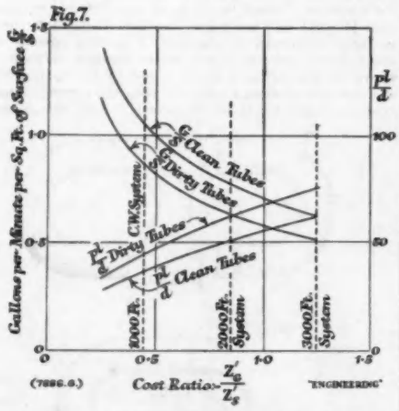


Fig. 7.



results of tests. The rainfall is defined as the feet of water falling on the base area of the tower per hour and is measured by the number of gallons per minute per square foot of base area.

The author's interpretation of Merkel's theory is explained in Section III, and a single curve is deduced and shown in Fig. 5, on this page, which appears to agree very well with the performances of towers of the hyperbolic type over the range of sizes found in practice. The constant for the curve was found from a special test carried out on the tower at Darlington, particulars of which are given later, and the results agree very well with a number of further tests at Darlington over long periods covering a range of wet-bulb temperatures from 33 deg. F. to 64 deg. F. and also agrees with

* "Recent Developments in the Design and Working of Cooling Towers," by T. J. Gueritte, *Soc. Ing. Civils de France* (British Section), 1927. "Modern Tendencies in Cooling Tower Design," same author, E.P.E.A. Technical Group, 1937.

† Coffey and Horne, "A Theory of Cooling Towers compared with Results in Practice," *A.S.M.E. Journal*, 1914, 1915, 1916, 1920. Lewis, "Evaporation of a Liquid into a Gas," *Mech. Eng.*, vol. 44, 1922. Robinson, "The Design of Cooling Towers," *Mech. Eng.*, vol. 45, 1923.

‡ *Z.V.D.I.*, vol. 70, page 123 (1926).

* *Loc. cit.*

† "Klip Generating Station," by V. Pickles and J. S. Trelease, *Trans. S.A.I.E.E.*, May, 1940.

* *A.S.M.E.*, vol. 58, page 627 (1936).

area, water quantity or size of tower from the conditions of minimum cost can be made without materially affecting the total cost. The mathematical explanation of this can be obtained from the analysis given above. In each case the total cost as affected by one of the above variables is expressed in the following form :—Total cost $= a\,z + \frac{b}{z}$ where z is the variable and a and b are constants. Let $z = q\,z_0$ where z_0 is the value of z for minimum cost. The value of z_0 is $\sqrt{\frac{b}{a}}$. Therefore, in general, the total cost $= \sqrt{ab}\left(q + \frac{1}{q}\right)$ and the ratio of cost for any value of q to the minimum cost when $q = 1$ is $\frac{q^2+1}{2\,q}$. Table II, herewith, shows the relative total costs as affected by the variable, for different values of q :—

TABLE II.

q.	Percentage Increase above Minimum Cost.
1·3	3·45
1·2	1·67
1·1	0·45
1·0	0
0·9	0·55
0·8	2·5
0·7	6·4

It will be seen that the variable, and therefore the capital expenditure, can be reduced 20 per cent. below the value for minimum cost without increasing the total cost as affected by the variable by more than 2·5 per cent. ; but, if a reduction of 20 per cent. is made on all three variables, the total fuel consumption will be increased by over 2 per cent. on the average, and the effect will be magnified under extreme conditions of load and dirtiness of the condenser. At the same time, while the limitation due to economy in initial cost is always present, there is a tendency to forget, after the plant has been in operation for some time, that the plant was originally designed for economy in initial outlay. It is therefore recommended that the plant should always be designed for conditions of overall minimum cost if possible.

(To be continued.)

ANTI-GLARE SCHEMES IN FOUNDRIES.

MANY ironfounders have provided anti-glare screening for their cupolas and other furnaces and numerous schemes have received the approval of the Anti-Glare Advisory Committee for the foundry industry, of which Mr. J. G. Pearce, the Director of the British Cast Iron Research Association, is chairman. The screening usually involves the top of the furnace, but, in many cases, the charging hole and the base are also screened. Men are, of course, required to work at the charging hole and base, and, in cases in which space is restricted, lack of ventilation may have an adverse effect on working conditions during the summer months. The Ministry of Home Security, which is represented on the Advisory Committee, is anxious that action should be taken in this matter well before the coming warmer weather, as otherwise output may be seriously affected by unsatisfactory working conditions, or by inadequate modifications to the screening improvised at the last moment. A note on the subject of the ventilation of anti-glare schemes is contained in the current quarterly *Bulletin* of the British Cast Iron Research Association. This states that foundries which do not operate into the black-out hours during the summer months, may find it possible to remove and store part of the sheeting, replacing it when required in the autumn. On the other hand, when cupolas are operated during the hours of darkness in the hot weather, some modification to the screening may be required, such as the provision of sliding or hinged shutters which can be opened during daylight, or the provision of louvres to improve ventilation during the black-out hours. In certain cases it may be found necessary to install fans to ensure an adequate supply of cool air. Where such measures are required, a supplementary scheme should be drawn up and submitted to the Anti-Glare Advisory Committee as soon as possible. The Treasury grant of 50 per cent., payable on anti-glare schemes, will also be paid towards the cost of approved schemes for ventilation. Any firms in doubt regarding the adequacy of their ventilation after screening, should communicate with the British Cast Iron Research Association, and a visit from an anti-glare officer of the Ministry of Home Security will then be arranged.

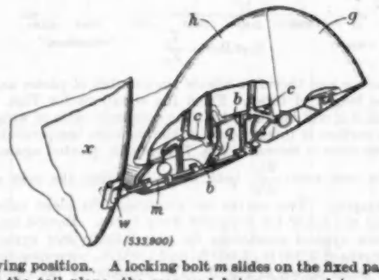
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case ; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

533,900. Folding-Wing Aircraft. The Fairey Aviation Company, Limited, of Hayes, and M. J. O. Lobelle, of Langley. (12 *Figs.*) December 13, 1939.—The aircraft is of the kind in which the wings are mounted so that they can be turned first about a horizontal axis and then about a vertical axis. When the wings are folded, the overall width across the tail plane and elevators is greater, and sometimes considerably greater, than the width across the folded wings, so that it is this tail width which determines the space occupied by the machine, for example, on the deck of an aircraft carrier. The invention facilitates the stowage of aircraft, with wings folded, on capital ships within the minimum space without penalising aerodynamic or operational efficiency. Each of the front and rear tail-plane spars is formed in two parts *b*, *c*, hinged together along a line parallel with the chord of the tail plane and elevators and with the longitudinal axis of the aircraft. The elevator tips *g* are moved automatically and simultaneously with the tail-plane tips *h* when the latter are folded upwards, provided that the elevators are set in the neutral position before folding. The hinged ends of the two parts *b*, *c* of the front and rear spars are formed with eyes which register with one another when the tips *h* are extended in the



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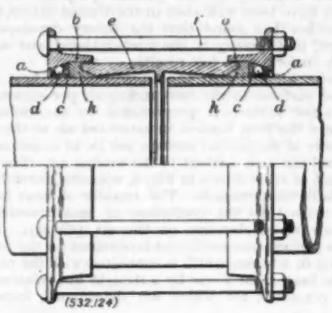
flying position. A locking bolt *m* slides on the fixed part of the tail plane, the rear end being arranged to pass through the eyes on the rear spar while the front end projects through the leading edge of the tail plane. Adjacent to the front spar the bolt carries a second locking pin which can pass through the eyes on the front spar. The bolt is shot or retracted by a forked lever *q* shaped so that when the parts are in flying position its arm lies between the fixed and folding portions of the tail plane, from which position it is pulled upwards to withdraw the locking pins. A compression spring around the locking bolt urges it towards the locking position, and the lever *q* carries a pawl which runs on a toothed rack to hold the bolt in its withdrawn position. The front end of the locking bolt *m* is provided with a saddle piece *w* to straddle the tip of the wing *x* folded against that side of the aircraft, and this saddle piece engages the wing tip until the locking bolt *m* has been fully shot. An interlocking device prevents the locking bolt *m* from being fully shot until the elevator and tail plane tips *g* and *h* are in their extended positions, and thus prevents the saddle piece *w* from freeing the tip of the folded wing *x*. (*Accepted February* 21, 1941.)

HYDRAULIC APPARATUS.

532,124. Pipe Joint. Victaulic Company, Limited, of London, and P. G. Johnson, of London. (3 *Figs.*) July 13, 1939.—The pipe joint is designed to maintain a high degree of fluid and mechanical tightness in spite of axial forces tending to separate the sections connected by the joint. The double-muff coupling shown is of the same general construction as usual in such couplings except that the angle of the internal conical surface *a* in each of the loose end flanges *b* is much smaller. The portion of the packing ring (originally integral) lying within the conical surface in each end flange is replaced by a separate joint ring *c*, of wedge section, made of rubber or similar composition. A large number of steel balls *d* are moulded in this ring, the size of the balls being such that they are tangential to the outer conical surface and the inner cylindrical surface of the joint ring at about the middle of its width. Circumferentially, the balls do not quite touch each other. The joint is assembled with a centre sleeve *e* and secured by bolts *f* in the same way, the usual packing rings *h* being provided to seal the joint. When the end flanges *b* are tightened up, the balls



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d ensure that the whole joint assembly is held firmly upon the pipes and any end load on either of the pipes tending to separate it from the other merely tightens up the assembly, since the balls become wedged in the annular wedge-section gap between the conical inner surfaces *a* of the end flanges and the cylindrical outer surfaces of the pipes. (*Accepted January* 17, 1941.)

MISCELLANEOUS.

532,646. Chain Link. Swan, Hunter and Wigham Richardson, Limited, of Walker, and W. McBain, of Newcastle-on-Tyne. (9 *Figs.*) September 18, 1939.—The ring of the link is composed of two mild steel U-pieces *a* and the ends of these pieces are cut off square, so that when the pieces are placed in the position shown in Fig. 1 and brought together, their adjacent ends fit closely against one another as indicated in Fig. 2. The supporting stud is constituted by two sleeves *d* joined together. In practice, the stud and sleeves are formed as a single steel drop-forging. The U-pieces *a* are of uniform diameter throughout, and the holes *e* in the stud are of substantially the same diameter as that of the U-pieces. When the ends of the U-pieces *a* have been inserted into the holes *e* so that they abut, they are held in contact by clamps. A welding current of about 20,000 amperes is now passed through the sleeves where the ends of the U-pieces adjoin by the application of a potential of about 4 volts to 5 volts, the currents being allowed to pass for about 30 seconds. With this procedure

Fig. 1.

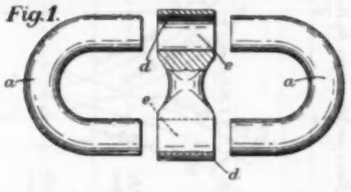
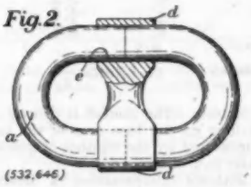


Fig. 2.



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there is little or no oxidation at the joints since, for practical purposes, air is excluded from contact with the plastic metal at the welds. After the welding operation, while the metal is still plastic, a forging pressure of about 1 ton per square inch is applied hydraulically to each heated part and thereafter the link is allowed to cool. In view of the plastic metal being imprisoned by the hydraulic pressure it is prevented from expanding and consequently receives a heavy forging effect. If there has been any expansion during the welding operation the forging pressure subsequently applied compacts the metal and restores it substantially to its original condition. Furthermore, the stud is joined to the ring. Surplus metal may then be trimmed off, and the completed link is annealed. The exclusion of air by this method produces an efficient joint. It has been found that a link made in the manner described has exceptional strength, and in a tensile test with a link made from mild steel $\frac{3}{4}$ in. in diameter, it was observed that fracture did not occur until a load of 21·4 tons had been reached. Even then failure did not occur at the joints. (*Accepted January* 28, 1941.)